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MORRIS ARBORETUM

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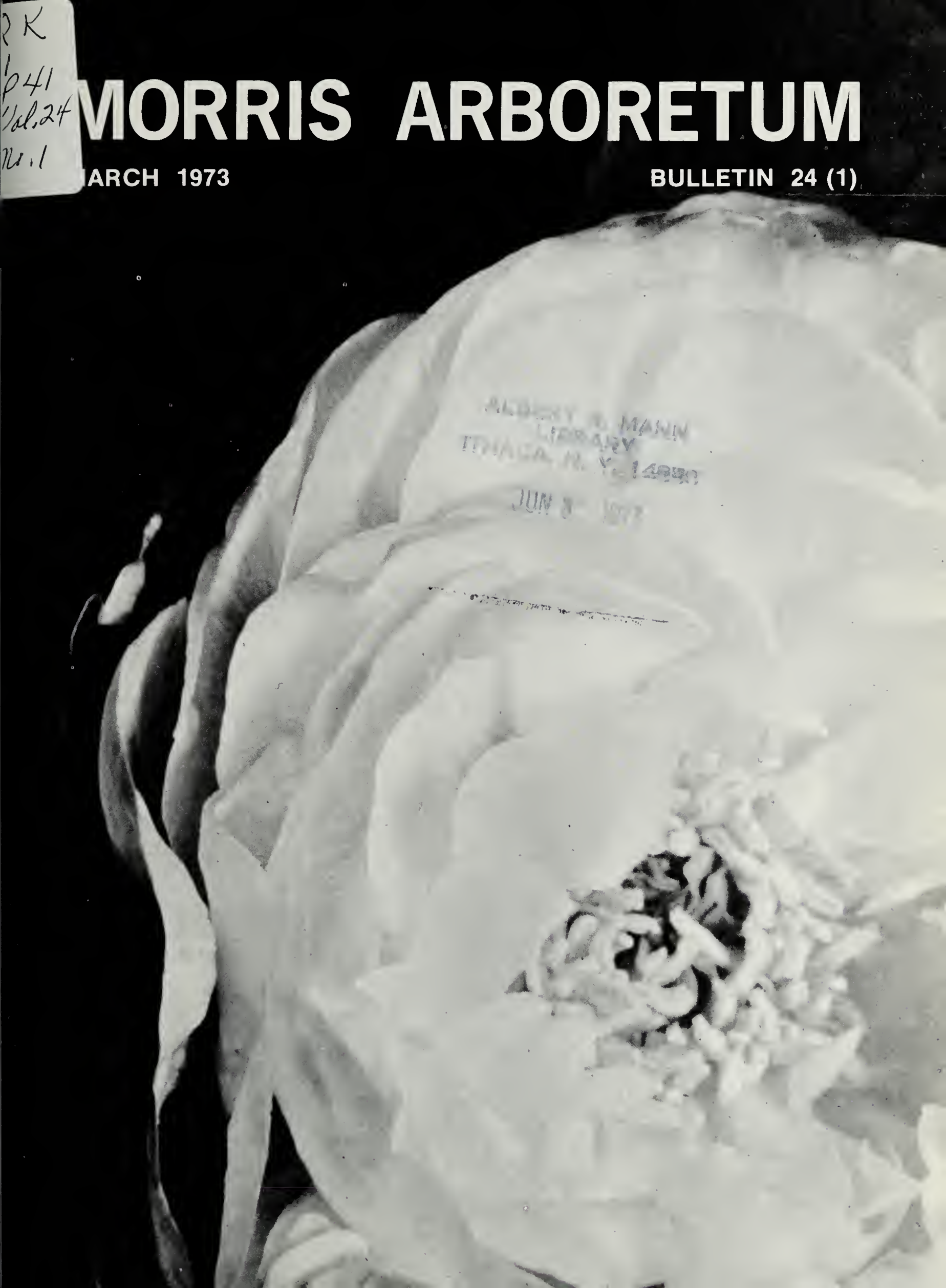

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THE ASSOCIATES, through whose interest and generosity *The Bulletin* and certain other undertakings of the Arboretum are made possible, is an informal group of individuals interested in encouraging and furthering the educational and research endeavors of the Morris Arboretum.

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CREDITS: Cover, William Wright, Arboretum gardener; Page 3, Woodcut from *Le jardin de sante*, 1539; Page 4, Photo by P. Allison; Page 5, Watercolor from *The Garden*, issue 46, Page 222, plate 980, 1894; Page 6, Photo by Helen M. Bauhof; Pages 8, 9, and 12, Photos courtesy of the Illinois Natural History Survey; Page 11, Graph courtesy of R. J. Campana; Page 15, Drawing from *Trees of Pennsylvania* by Hui-Lin Li.

COVER: *Paeonia*, named for Paeon, healer of the gods, is queen of the May in many gardens because of its rich variety of form, fragrance, color, and foliage. A potion of peony seeds and wine or mead is said to drive off nightmares.

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MAN AND NATURE

THE ARBORETA'S ROLE IN A CHANGING SOCIETY

DR. RICHARD W. LIGHTY,

Coordinator of the Longwood Program in Ornamental Horticulture at the University of Delaware, was the stirring keynoter at the first meeting of The Associates of The Morris Arboretum in January. We are grateful to him for supplying this precis of his talk.

We have gotten progressively more removed from the ecological systems of which we were once a part. We call this progress. Its physical manifestation is the removal or radical alteration of anything that causes us *pain, discomfort, inconvenience*—and now we have reached the point where even the lack of inconvenience no longer suffices—we demand to be surrounded by *pleasure* and to *enjoy our environment* so that we may be *happy.*

So we search feverishly for the key to happiness. We build broad roads so that our pursuit of happiness can be swift in high-powered automobiles, and, in doing so, cut through forests; gouge out hillsides; confine flashing streams to cement channels; pollute the air with exhaust and the lakes and streams with the sewage of our petroleum, iron and coal industries. We pursue a Madison Avenue mirage of happiness in the suburban splendor of a giant eggcrate with thermostatically controlled atmosphere, intercoms with optional soothing music in every room, heated garage so the car won't get cold, and where the only painful things are mowing the grass and deciding how and when to trim the bushes.

Now, what we are victims of—and I'm still trying to understand how it came about—is a slow but progressive *desensitization* of people to the joys of their evolutionary habitat, and a rapid and ever-changing sensitization to things that some man or some institution can supply.

"But," you say, jumping to your feet; "you can't

be speaking of us, the friends and Associates of The Morris Arboretum." And, in truth, I'm not.

Any one of a group of bird watchers, orchid growers, flower painters, mountain climbers, poets, musicians, artists or writers *already* belongs to the group I call *sensitive, human* beings. These people can cross disciplines with facility. A poet can enjoy a plant as much or more than the person who grew the plant. Artists have taught me much about the wild and the trained landscape. But this group of sensitive people is a woefully small one and the problems that face us are of gigantic proportions.

". . . . . *the suburban splendor of a giant egg crate.*"

I don't want to stop the bulldozers. We do need many of the things they lead to. But what I want to do is direct them, and this requires *sensitivity* and *you* are the people who can propagate this in this community.

A person who has potted, watered and otherwise cared for a plant so that it fulfills its promise has already started down the road to sensitivity.

If you know that a good lawn is a combination of many living things that, as a working whole, is in concert with the climate, the soil, and the people who use it, can you fail to see that the mowing is part of the making? Can it escape you that the process is inseparable from the product, and can be fully ninety percent of the joy?

When a young kid sticks a coleus stem in water and in a few weeks pots up *his* new plant, can he fail to be sensitive to the integrated complexity of it? You'd be surprised how many college students come to horticulture by the propagation route. Grade schools and colleges fail. They teach dry subjects in dry ways and often use dull people. But then they don't even consider their role as one of sensitization. They are more concerned with knowledge and skills, the simplest of the things we must master to realize our human potential.

So **the process of sensitization remains the work of museums, zoological gardens and arboreta.**

In the will that established the Morris Arboretum, the word garden was used. And a garden, like a symphony, a painting, or a poem, is a way of communicating things that can't be expressed by words alone. It is the only way we *can* communicate certain things that are essentially human. If you don't believe me, try to describe a garden in straightforward terms to someone who has never felt one.

You have here at The Morris a great collection of plant materials on a varied and extensive piece of ground. You have an initial purpose, a tradition and a new dedication. You have a site which literally shouts, "Public Service," and you have here tonight a group of people individually, and for many reasons, dedicated to this institution and its role.

Right now we are in a valley; it is upward in all directions. Many hills are yours to climb, and you who are here tonight, are those who will scale the peaks.

So this group constitutes the expeditionary force that represents the Morris Arboretum's dedication to help make the *human society* worth the human lifetime.

PONCIRUS TRIFOLIATA

HARDY ORANGE

G. BARLOW ABRAMS

One of the most overlooked ornamental plants for the American garden is *Poncirus trifoliata* (L.) Raf. Hardy Orange. *Poncirus* is considered by many to be too exotic in appearance for most garden settings. (Indeed it is the only species in its genus.) The habit of growth is stiffly upright with angular branches protected by thorns and spines. The branches are bright green and very attractive in the winter, while in the spring they provide an excellent background for the two-inch fragrant white flowers which are produced in the axils of the spines before the leaves unfold. In the fall of the year, the yellow-orange fruits, not considered edible because of the strong bitter taste, assume the focal point adding still another seasonal interest. The fragrance of the downy fruit is an added dividend. A bowlful of them provides both perfume and beauty indoors.

Hardy Orange is used in the south as a rugged hedge because of its dense growth and prominent spines. Farther north it is grown as a specimen in protected areas. Displayed against a sheltering wall, *Poncirus* makes a truly dramatic effect. With the advent of more modern architecture *Poncirus* is finally being recognized for its true beauty.

Prior to its use as an ornamental, Hardy Orange was used principally as stock upon which grafts of Common Orange were made. Hybrids between *Poncirus* and the Common Orange, *Citrus sinensis* Osbeck, have been produced and are called Citranges. These are grown for home use in the cotton belt states north of the normal limits of orange. The cross with *Fortunella japonica* Swingle produced the Kumquat. Hybrids are also produced with other citrus fruits such as sour orange, grapefruit, lemon, limes and Kumquat.

Hardy Orange is adapted to the rather rich somewhat moist sandy loam soils. The soils must be acid and this can be achieved by incorporation of leafmold or peat moss periodically. Other cultural requirements are minimal. Pruning is for training and should be done after flowers bloom in late April and May. If Hardy Orange is going to be used as a hedge, it responds to shearing and forms an impenetrable barrier.

P. trifoliata is hardy in the Philadelphia area, but can be grown as far north as Boston if given proper protection. It was introduced into the United States in 1850 from Korea and north China, but is reported also from Nepal and Japan.

This interesting plant for all seasons may be easily propagated from fresh seed or from cuttings of half-hardened stems.

The last American Elm of any stature at the Morris Arboretum was cut down this winter, a victim of Dutch Elm Disease. It was only fifty-two years old but was a stately tree. Apparently starting as a natural seedling, it grew next to the stream just below the spring house near Hillcrest Avenue.

There are two younger seedlings farther down the stream that are about ten to fifteen years old. They will receive the preventive maintenance program outlined by Dr. Campana in an effort to save them.

Gordon A. Brandes

SYSTEMIC CHEMICAL TREATMENT FOR DUTCH ELM DISEASE CONTROL:

WILL IT WORK?

by

Richard J. Campana

Department of Botany and Plant Pathology,
University of Maine.

From its history of spread and development in Europe and North America, there is nothing to indicate that the Dutch elm disease can be contained. The ecological forces at work are such that it is clearly beyond the capacity of man to prevent massive and often accelerating rates of infection in populous elm stands. These forces involve balances in population dynamics among at least three living species: (1) the elm (usually *Ulmus americana* L.); (2) at least one, and sometimes two, insect vectors (the introduced smaller European elm bark beetle, *Scolytus multistriatus* (Marsh.), or the Native elm bark beetle, *Hylurgopinus rufipes* (Eichh.); and (3) the causal fungus (*Ceratocystis ulmi* (C. Buisman) Moreau). In a broad sense the Dutch elm disease is a man-made problem. Once sporadically distributed mostly along streams, the American elm was planted extensively as pure stands in cities and towns throughout eastern North America as an urban or suburban "tree monoculture." Having established the elm as "the" urban tree over all others, inadvertently we next introduced from Europe (*circa* 1905) the European elm bark beetle, and later (*circa* 1930) at least one virulent strain of the causal fungus. Thus, the basic factors involved in this devastating epidemic of elm populations are: (1) extensive stands of closely spaced, highly susceptible trees often connected by root grafts; (2) an insect vector capacity enhanced by addition of the European beetle; and (3) presence of the causal fungus. These were combined under climatic conditions favorable to the proliferation and development of both the pathogen and its vectors. The diseasc is not restricted to urban elm stands; most native elms of field, stream and forest are highly susceptible and just as badly affected. The difference is that volunteer elms on open land develop naturally from seeds cast annually, whereas groups of elms lining streets, or used as specimen trees were usually established through plantings of clonal stocks, and most often at one specific time. Thus, there are significant differences between natural and horticultural elm populations with respect to site, spacing, numbers, age, variation in susceptibility, etc. Therefore, for various reasons, most urban elm populations may be reduced beyond restoration,

whereas natural ones will be replaced in part by natural seeding. The new natural populations will be reduced in size, with little or no regularity of spacing in spite of what man does or does not do in attempts at disease control. Thus, whatever we do is seen either as a delay of disease incidence in relatively small selected elm populations, or as the treatment of individual trees of sufficient value to warrant intensive control efforts.

In 1956 (1) I tried to design a blueprint for "community-wide control" of the disease with only two control methods (both indirect), but now I see little prospect that satisfactory disease control (saving most of the elms) will be achieved very often or for very long throughout extensive elm populations. Such control now appears possible only with complete and intensive application of at least five control methods on limited numbers of highly valued trees (2). These methods are: sanitation; dormant spraying; severance of root grafts; early removal of single-branch infections; and fungicide applications for internal action. At least two of these methods, (early surgery, and use of systemic chemicals) are direct, and it is the latter with which this paper is concerned. The concept of integrated control is still valid even where systemic chemicals can be used effectively to help prevent infection, because no single control measure has been demonstrated to be completely successful. Even if the application of systemic chemicals to diseased trees could result in complete recovery, re-infection might well nullify original curative efforts. At least with present knowledge and in the absence of greater certainty in the efficacy of chemical treatment, an integrated control approach has the merit of enhanced security.

Based on early field tests, there are two highly promising chemicals for the control of Dutch elm disease at the present time. The systemic fungicide Benlate (benomyl), has been tested extensively by many plant pathologists and continues to show promising results. The other, an antibiotic known as Nystatin, has been tested less extensively and is reported to be effective in disease control also.

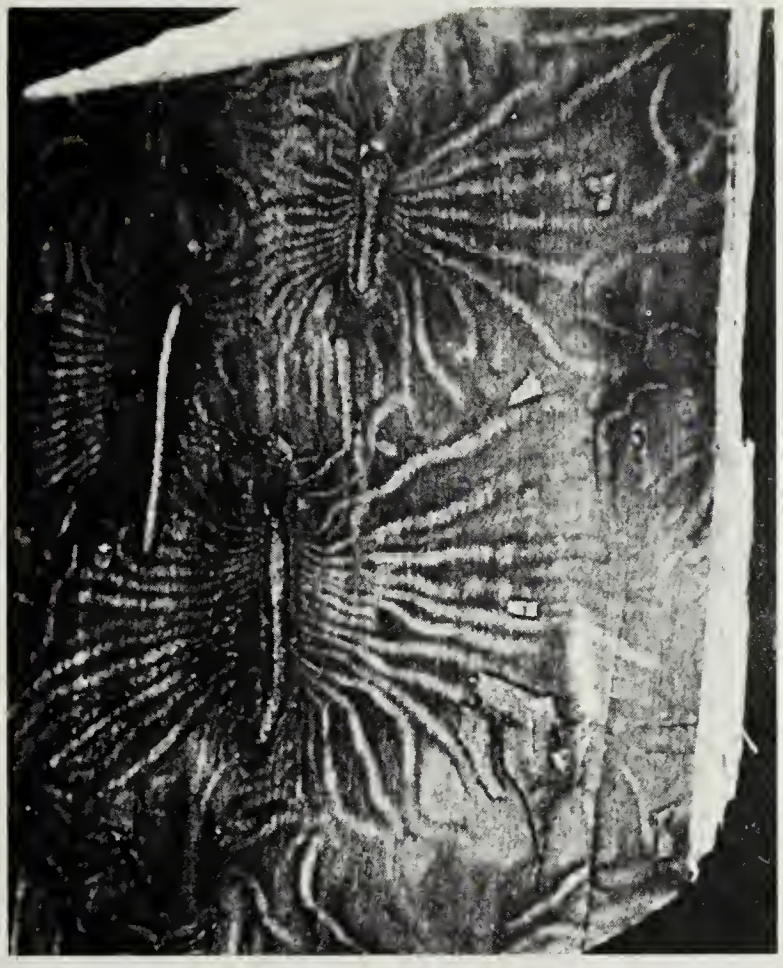
IS BENLATE SUITABLE AS A SYSTEMIC FUNGICIDE?

For at least the past thirty years plant pathologists have sought in vain a suitable systemic chemical to prevent or arrest Dutch elm disease. Hundreds of chemicals highly toxic in the laboratory against *C. ulmi*, failed to arrest the fungus in inoculated elms. Some of the reasons explaining such failures were reviewed in an earlier paper (3) on the requirements for a suitable systemic fungicide.

Within the past five years Benlate was found to be effective in preventing Dutch elm disease with applications by soil amendments, trunk injections or foliar sprays. A use permit issued by the U.S. Environmental Protection Agency in March of 1972 for the control of Dutch elm disease, was restricted to applications by trained and licensed arborists using specific methods of application. How well does Benlate meet requirements for a suitable systemic fungicide?

1. *Is it toxic to the fungus in elm tissue?* The chemical is quite effective in preventing infection, but most results indicate only partial success or failure in arresting the fungus after infection is well established. Post-infection treatment with Benlate applied by Maujet injection is often not recommended if more than five percent of the crown is visibly wilted before

These American elms, planted in a "tree monoculture," are dying from the combined forces of Dutch elm disease and phloem necrosis, another disease.



The Dutch elm disease fungus is carried from tree to tree by bark beetles. These are the brood chambers of one of them.

Dutch elm disease symptoms on twigs. The twig on the left is normal. The wood of the two at right is typically discolored.

treatment. However, most published data are based on use of the chemical in an aqueous *suspension*, in which only a minor fraction of the fungicide is in the dissolved state! The particulate matter in the suspension clogs vessels through which the solubilized fraction must move to get where it can be most effective. Thus, Benlate in suspension appears to have a low capacity for being widely systemic. But the degree of fungitoxicity in elm tissue is still unresolved, since there are no carefully designed studies to answer this question. Tests on a new, solubilized Benlate, especially those involving pressure injection, have been initiated too recently to provide an answer here. My experiments in using solubilized Benlate with pressure injection in 1972 produced evidence that the fungus may not be killed completely with post-infection treatment. With good distribution, it is easy to visualize death of fungus spores as they are exposed in open vessels; however, it is also easy to visualize impacted hyphae of the causal fungus deep in cellulose layers of wall tissue of cells not contiguous to open vessels. Can we be certain that such hyphal structures will be killed? Is it possible for the fungus to "ride out" the Benlate "storm" in such tissues until the chemical loses its punch, and then emerge from the "woodwork" to continue the infection process? Will the disease symptoms so visibly arrested in July and August appear, or fail to appear in the following June? These and many other questions have yet to be answered; we can say with confidence at present that fungitoxicity in elm tissue has been demonstrated beyond question only before an infection is well established.

2. *Is Benlate stable; does it or its derivatives retain toxicity?* All of the evidence points to its early transition to MBC (methyl-2-benzimidazole carbamate) reported to be fully as toxic as Benlate *per se.* On this point, the fungicide clearly meets the requirement.

3. *Is Benlate mobile?* There seems little question here that it is; certainly in upward mobility, reliable bioassay tests show that fungitoxicity can be detected in strength far from points of injection. However, as noted above, mobility can be impaired by clogging of vessels, and there is evidence that this happens often with non-solubilized material. But even though mobility is now assured in the new solubilized form, can we be certain that Benlate will get into all of the branches where infection could be present? Unfortunately, even with pressure injection of the solubilized form, bioassay tests indicate difficulty in detection of fungitoxicity in many small branches where infection is possible.

4. *Is Benlate residual? Does it remain long enough in the plant system to be effective?* There is no body of reliable data on effective longevity of toxicity in elm tissue, even though it is reported to persist in some plant tissues up to 18 weeks. Unfortunately, the same physical factors that favor mobility may favor elimination from the vascular conduits through which the infecting fungus moves. Time is critical here and its significance depends on whether the treatment is designed to be preventive or curative. If preventive, the chemical must be applied in early spring (late May or early June in most places) and remain effective over a period of 4-6 weeks (into July in most places). If curative, initial strength and rapid mobility might be decisive factors to achieve rapid and complete toxicity to the fungus. But, as noted above, in post-infection application, complete toxicity to all fungus elements of an established infection is unresolved.

5. *Is Benlate phytotoxic?* In concentrations necessary to be effectively fungicidal, does it cause side effects damaging to plant tissues into which it must move as a systemic? All reports indicate little or no phytotoxicity at levels well above those required; however, some damage is reported at unusually high dosages in applications both of emulsified and solubilized forms. Probably because the initial evidence of lack of significant phytotoxicity is so encouraging, this point has not yet been evaluated critically. To the extent that foliar application by spraying continues to show promise for preventive control, a critical study here to establish threshold levels of phytotoxicity is essential. Also, in flushing of Benlate emulsions into drilled holes in bark and wood, with resulting encrustation of exposed tissue surface by precipitated particulate matter, there is some possibility of localized toxicity. However, it may be difficult, to separate apparent toxicity from wound-tissue reactions and subsequent microbial colonization. Many such wounds in 1972 healed quickly; thus localized tissue damage by chemical toxicity or trauma is not considered serious. In effect, Benlate appears to satisfy the requirement for relative non-phytotoxicity.

USE AND RESULTS

One of the most hopeful signs that a satisfactory systemic chemical may now be at hand, is the wide variety of research being done by so many pathologists involving testing of new techniques to put Benlate into vessels of elm, the main sites of initial infections and ultimate spread of the causal fungus throughout the tree. When first used against Dutch elm disease, Benlate was incorporated into the soil to be absorbed by the root system of the tree. Its effectiveness by this method was based on sustained presence of the fungicide over long periods of time, in some cases exceeding a year, as well as on uniformity of distribution throughout the vascular systems of the trees. However, soil application is disadvantageous for many practical and economic reasons.

Foliar spray by mist blower at the rate of 8 pounds per hundred gallons of water was effective in preventing new infections both in Wisconsin and Michigan (4, 5), but is not considered to have value against established infections. Systemic fungicides applied to foliage have limited ability to move downward in woody tissues, where the causal pathogen becomes deeply established. Therefore it is not likely that infection could be arrested, unless the fungus were limited in its distribution to relatively small twigs when the chemical spray was applied. Thus, in spite of its promise, spraying is limited to prevention of infection, and has potential for environmental damage.

Stem injection of Benlate poses no environmental hazard; in addition, it is more promising against established infections than any other method. In most cases methods involve direct stem or root application of water emulsions of particulate matter, encapsulated "pills," or water-acid solubilized chemical; injections are by pressure, or gravity flow. In all cases, the chemical is introduced by mechanical devices directly to xylem vessels exposed by drilled holes or incisions.

The earliest successful stem injection technique involved the use of the Maujet injector. Thin metal tubes hammered into tree trunks to a precise depth, are designed to allow liquid flow directly to vessels exposed in the wood of the current season. With this method, success depends largely on precision of timing and positioning of tubes. Much success and many failures are reported. From personal observations, certain disadvantages seem apparent. The method is time consuming and thus expensive; it delivers a limited amount of chemical; the emulsified chemical clogs the openings and prevents or delays absorption; feeding cups in place are subject to vandalism; and the method requires a degree of patience, understanding and precision not conducive to treatment of large numbers of trees. In spite of this, many elms have been saved because of it, and modifications may bring enhanced efficacy. In practice, the method is most effective in prevention, but has limited success against established infections.

Perhaps the most exciting development in stem injection of Benlate was the recent use of solubilized material applied under pressure. Several laboratories have developed similar methods. In our cooperative research with the U. S. Forest Service, acid-solubilized Benlate is forced under pressure by nitrogen gas (40-70 psi) through tubing and metal feeder pipes in-

to small incisions made by chisel in the outer one or two rings of the xylem. The fluid chemical, whose volume is based on tree diameter, moves into the tree in 20-30 minutes. This technique has both advantages and limitations. Since the chemical is forced into the tree in a liquid form, there is a high probability of fast action, high toxicity, and wide distribution. However, it is time-consuming and costly as with the Maujet technique. Also, speed of distribution could be a liability rather than an asset, if the chemical is swept out of the tree too fast. In spite of high expectations for uniform distribution, there is some evidence suggesting difficulties here. The method was first field-tested in 1972. Preliminary results indicate significant progress in arresting visible progress of disease, but final evaluations cannot be made until June or July in 1973.

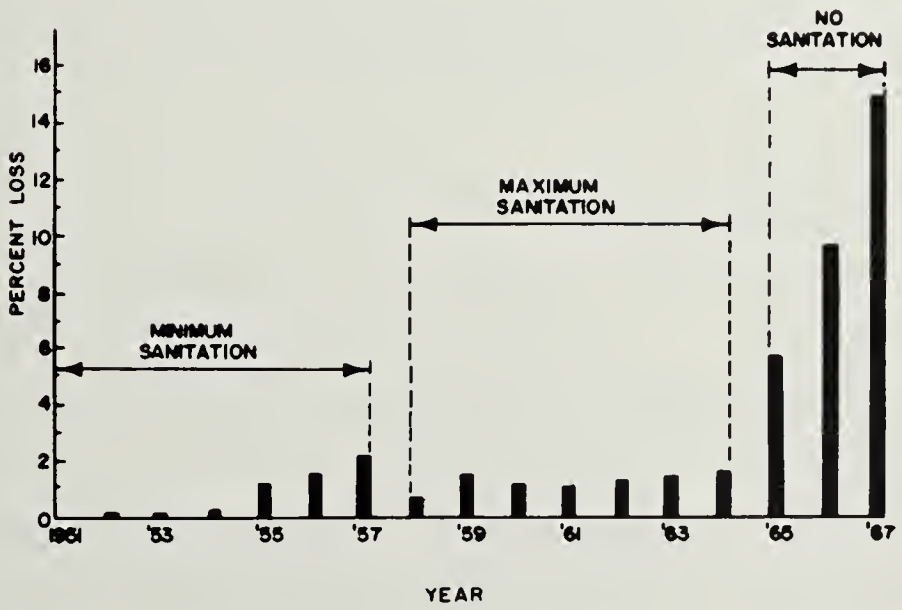
A novel approach to stem injection was initiated in 1972 by the Elm Research Institute with which the writer is working cooperatively. Holes (½ in. diam., 2 inches deep) are drilled around the tree 6 inches apart. Iron fittings with hose nozzle attachments are screwed tightly into holes to a depth of 1-1½ inches. Hosing connecting all of the fittings is connected to a two-gallon, hand-pump garden-type spray can, then the injection is made under pressures up to 40 psi. As with the Maujet treatment, the use of emulsified material results in conspicuous clogging of holes and vessels. Also, the bulk of the suspension is fed too deeply into the wood for maximum distribution into vessels of the current season, and most may be deposited in wood spaces of no significance for disease control. However, with solubilized Benlate, and improvement of the injection delivery, this method has much promise for the homeowner.

CURRENT RECOMMENDATIONS

But what is the commercial arborist, the municipal forester and the tree owner to make of all these new developments? How can the new information on chemical control be used to advantage? The evidence is clear that Benlate poses bright prospects for control, but caution is urged. It should be used experimentally within the provisions specified by the EPA in its approval: i.e., by trained and licensed arborists, as a protective spray or by stem injection through any method allowed by EPA. The following guidelines[1] are suggested for maximum protection of elms not known to be diseased.

1. Continue to practice thorough sanitation in areas of trees to be protected (i.e., eliminate dead, diseased or weakened elm wood in trees or on ground);

[1] It should be clear that all use of Benlate is still essentially experimental; these suggestions are based on limited but promising, data. Further critical research is essential before firm recommendations are warranted.



Sanitation is still one of the most important elements of an integrated control program. Much greater losses may be expected if it is abandoned. (1965-67 left.)

Another important part of an integrated control method for important specimens is the dormant spraying of methoxychlor.

2. Apply dormant methoxychlor spray as recommended by USDA (i.e., at least before leaf emergence; before flower emergence is preferred);

3. Sever mechanically or treat chemically potential root graft connections between closely-spaced (50 feet) trees.

4. Apply Benlate by one of the following methods:

a. Apply foliage spray of Benlate as recommended by University of Wisconsin (8 lbs. of formulated Benlate per 100 gals. of water; 2-3 gals. per tree; mist blower recommended); or

b. Use injector tubes (Maujet type) with cups of about 2 oz. capacity; use Benlate as recommended by Virginia Polytechnic Institute and State University (2 lbs. per hundred gallons of water); or

c. Use drilled holes with nozzles, tubing and pressure spray can as recommended by the Elm Research Institute (2 lbs. per 100 gals. of water).

For therapy of diseased elms in early stages (not more than 10 percent crown visibly wilted), the following guidelines may be of interest, but little hope is currently offered for cure of such trees with chemical treatment by itself:

1. Prune the diseased branch back to the main trunk as quickly as possible; removal within 24 hours is recommended (this treatment is recommended only for single branch infections);

2. Stem inject with Benlate as indicated above with heavy application, concentrating on that side of the tree affected. If using the Maujet injector, make new injections two or three times at 10 day intervals.

As a final note of caution, chemical treatment should not be used as a substitute for sanitation, spraying, root graft treatment, or pruning out a diseased branch, but as a supplement. Benlate and other systemic chemicals are on trial; prospects for control have never seemed better than at the present time, but only careful study and cautious evaluation can resolve the questions raised. In the final analysis, the record will speak for itself.

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BOOK REVIEW

TREE MAINTENANCE by P. Pirone. 4th ed. Oxford University Press. New York. 1972. 574 pp. $15.00.

Dr. Pirone, Senior Pathologist at the New York Botanical Garden, did everyone interested in trees a favor when he conceived this book many years ago. Now that this edition is out, that favor has been refreshed.

The pesticides recommended no longer include DDT and some of its relatives; the equipment section has been improved; and the geographical coverage has been expanded somewhat. But these improvements pale before the basic conception of the book. That is to familiarize the reader, be he amateur gardener or professional plantsman, with the essential nature of the tree, the essential nature of its troubles, and the essential procedures for restoring and maintaining tree health.

Tree Maintenance should be on every serious gardener's shelf, and every municipal politician's shelf too for that matter, if only for a single purpose: to provide some means of assessing the competency of an "arborist" who might work in his garden or along his streets. If the tree man is not thoroughly familiar with the book and the principles it embodies in the first half, he should not be hired.

There is another distinct advantage in ownership of the book. It is invaluable in the *planning stages* of a garden or beautification program of a community. Here can be found information about specific attributes of dozens of trees.

A third advantage in ownership: the extensive bibliographies at the ends of the chapters have been refurbished so that the reader may continue the exploration of an abundance of topics about trees.

P. Allison

MORRIS ARBORETUM MONOGRAPHS

A SERIES OF SCHOLARLY WORKS ON BOTANY AND RELATED SUBJECTS

Unless out of print, books are available postpaid from the Morris Arboretum, if remittance accompanies orders.

THE BEGINNINGS OF PLANT HYBRIDIZATION. Conway Zirkle. 1935. 231 pp. University of Pennsylvania Press. (Out of print)

CONSERVATION OF RENEWABLE NATURAL RESOURCES. University of Pennsylvania Bicentennial Conference. Raphael Zon et al. 1941. 200 pp. $7.50. University of Pennsylvania Press. Reissued, 1969, by Kennikat Press, N. Y.

THE GENUS PHLOX. Edgar T. Wherry. 1955. 174 pp. $4.50. The Morris Arboretum.

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PREPARING HEMLOCK HERBARIUM SPECIMENS

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and

Gregg Beaty

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Standard herbarium techniques of collecting, pressing, drying, and mounting a desired plant segment produce permanent reference collections of most species of higher plants. Two notable exceptions not provided for by these techniques are spruce *(Picea)* and hemlock *(Tsuga)*. When an ordinary herbarium preparation of these is consulted, one usually finds a branch skeleton with a packet of its needles. The needles will not remain attached unless special techniques are used or unless the whole specimen is glued to the herbarium sheet.

This article will be chiefly concerned with attempts to achieve preservation of hemlock *(Tsuga canadensis* (L.) Carr.) for an herbarium.

Santamour and Kettlewood reported methods of treating cut hemlock specimens [1]. They found that a glycerine impregnation method was better than either a glycerine absorption or a copper salt impregnation method.

The impregnation method consisted of submerging cut specimens in a 50 per cent aqueous glycerine solution and soaking them for three weeks. Specimens were then rinsed and pressed for two weeks at room temperature.

The absorption method consisted of placing the basal ends of specimens in the same sort of solution so that it was translocated into the needles. This method generally resulted in poor color and needle retention.

A third method, that of using copper chloride and lactic acid in solution, was helpful in preserving some natural color in treated specimens, but the results did not justify the added inconvenience.

Experiments and Results

In an effort to improve the quality of hemlock specimens, several modifications of the impregnation method were examined. These included lowering the glycerine concentration, shortening the soaking period, and increasing the temperature during pressing and drying.

Terminal cuttings ten inches long, four per treatment, were collected in mid-September at the Morris Arboretum. Sixteen at a time were submerged in 5 liters of a glycerine solution (10 or 50 per cent) in 10.8 liter polyethylene containers. Newspaper was tied over the container tops to prevent undue evaporative losses. The cuttings were rinsed and blotted before pressing. One press was heated on a dryer by five 60 watt bulbs five inches below it. The temperature,

[1] Santamour, Frank S., Jr., and Harry C. Kettlewood. 1963. The preparation of spruce and hemlock herbarium specimens. Morris Arboretum Bulletin 14:15-17.

measured at the center of the pack, soon reached 55°C and remained there. The other press was left on an unheated dryer at room temperature (measured, varying between 15 and 20°C). Press time was two weeks. Specimens were examined when removed from the presses and again one month later.

The results are summarized in Table I. They reveal a definite pattern and all the factors contribute to the final rating of a specimen. Only those specimens soaked in 50 per cent glycerine approached herbarium quality. They were superior to those soaked in the lower concentration, but even these failed when subjected to heat during pressing. None of the 10 per cent glycerine treatments was satisfactory. In general, longer soaking is superior to shorter. It should be noted that needle color was brownish-green in all treatments except the controls (brown).

Discussion

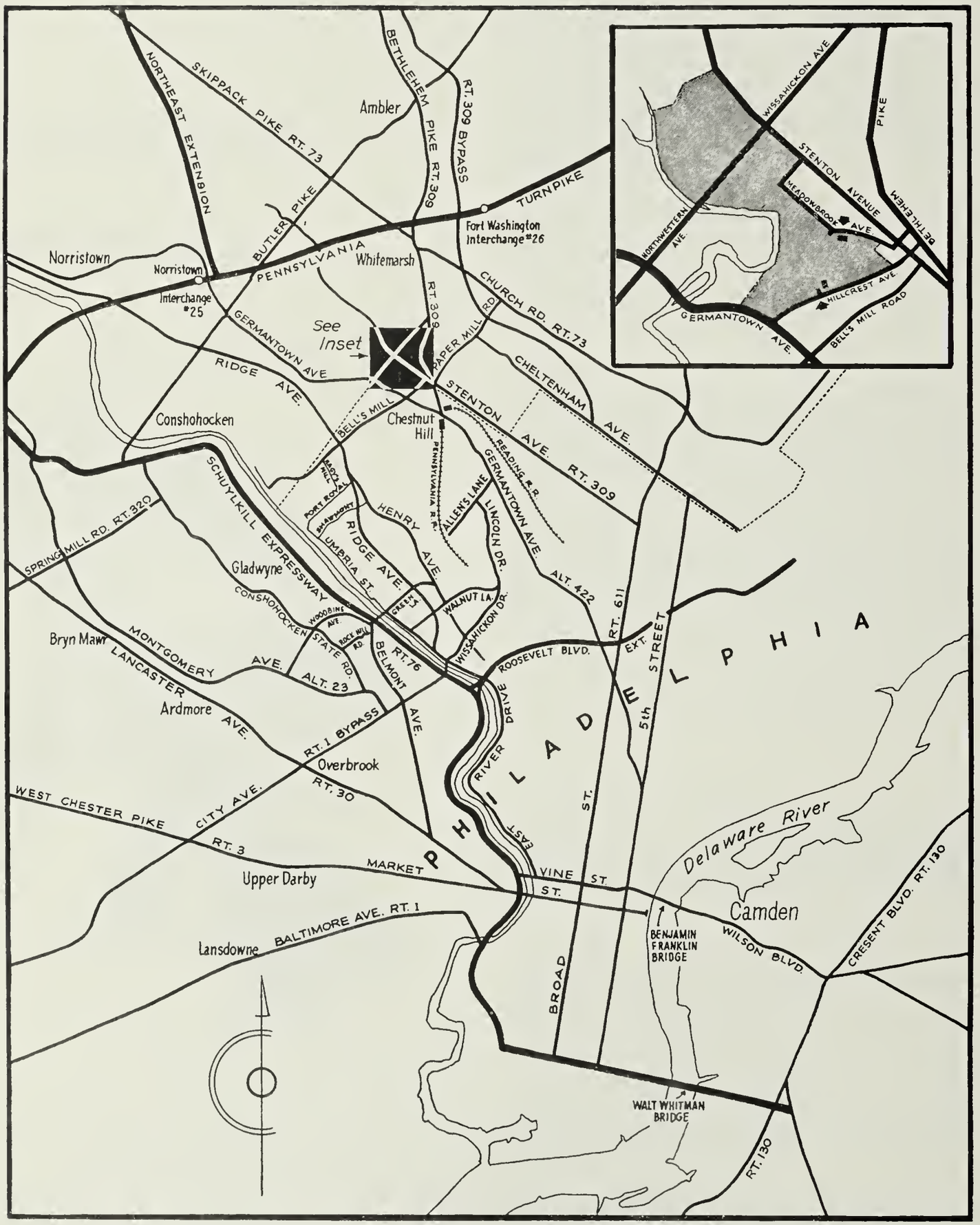
Santamour and Kettlewood used a three-week soak period and suggested that even a longer one would be beneficial. Our data support this view. They used only one concentration of glycerine, 50 per cent. Our evidence of the effects of concentration is so strong that we suggest that even higher concentrations might produce better results. Although Santamour and Kettlewood gave no data regarding temperature during pressing, we would suggest that high press temperatures should be avoided in future attempts to improve the techniques.

Table I. The influence of glycerine concentration, soak period, and temperature on needle retention of *Tsuga canadensis* herbarium specimens. (4 replicates per treatment)

Glycerine %	Soak Period	Press Temperature	
		Room Temperature[a]	55°C
0	0	1[b]	1
10	1 wk	1	1
10	2 wk	2	1
50	1 wk	3	1
50	2 wk	3	2

[a] 15–20°C.

[b] 1, Poor: Little or no needle retention. 2, Fair: about 50% retention. 3, Good: 75–100% needle retention.



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MORRIS ARBORETUM

JUNE 1973

BULLETIN 24 (2)

Monarda kalmiana

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THE MORRIS ARBORETUM BULLETIN

Volume 24 Number 2 June, 1973

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COVER: from Frederick Pursh's Flora Americae Septentrionalis, *1814.* Monarda kalmiana *Pursh is a synonym of* Monarda didyma *L. See article, "Five Early Botanists," page 28.*

EDITOR: Hui-Lin Li ASSISTANT EDITOR: Susan B. Blum

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On the Morris Arboretum Bulletin

The pieture that accompanies this editorial was featured on the eover of the *Bulletin of the Morris Arboretum*, Oetober, 1937. The photo-illustration was exeeuted by Gustave Liebseher and portrays the iron weathervane which topped the summerhouse in the Rose Garden.

That weathervane no longer exists, but it is somehow fitting to inelude this old memento as we talk about the *Bulletin*, its past, present, and future.

The *Bulletin* began nearly 38 years ago as a quarterly magazine of eight to ten pages, and eontained information on the Arboretum's eolleetions and aetivities. It has continued its quarterly stride but for a break during World War II.

Over the years, even as the size changed to a greater 16 to 24 page issue, the eontent underwent changes, too. From its humble beginnings as a medium of reportage, the *Bulletin* expanded its format and intentions. Readers benefited from in-depth artieles by the staff and other authorities on botanieal and hortieultural subjects. The *Bulletin* was never intended as a vehiele for teehnieal reports, and the Arboretum staff eontinued to publish their researeh papers in technieal journals and as monographs (some in the Arboretum Monograph Series). But more ambitious artieles and short researeh reports were ineluded in the *Bulletin* format.

Looking baek we may say that the *Bulletin* has had some sueeess in its intention of publishing and diffusing knowledge about plants—a funetion whieh was speeifieally spelled out by the founders of this arboretum. Quite a number of our artieles have been reprinted by request in other journals. Our botanieal papers have been regularly abstraeted in international abstract journals. Information eontained in our magazine has frequently been sought by libraries and individuals. And recently the *Bulletin* joined the ranks of an international array of periodieals whose information is tabulated and made available in mierofilm editions.

We ean point to our past with some pride. But even while doing so we must assess our status and look to the future.

In this age of great soeial ehange and new environmental awareness, the *Bulletin* needs eontinuous self-searching to find out how to improve itself, how to better perform its role. In that self-searehing we have arrived at some eonelusions, some hints of veetors to the future.

The *Bulletin* is a kind of window onto the world of plants. Through it we frame the reader's view, direct his attention and, hopefully, enlighten his world. But it is important that the view not be a privileged one. With renewed effort we will seek to present our information in the most readily understandable form possible. Through an inereased awareness of layout and design, and with a greater use of illustrative materials, we hope to further elarify and illuminate the reader's view.

Among the subjeets we propose for the eoming issues are reports on research at the Arboretum, new views of the Arboretum and its resourees, original or innovative ideas in gardening, features of timely importanee in the preservation of the greater "Green World," and, with an eye to the eoming Bieentennial, the *Bulletin* will feature artieles on some of the plants and personalities that influeneed young, green America.

But finally, the *Bulletin* is for you. We hope our readers will join us in making this publieation responsive, informative, and interesting. We invite your eontribution of artieles and ideas. And your suggestions are always welcome.

Hui-Lin Li and Susan B. Blum

THE MICHAUX QUERCETUM...

The Michaux Quercetum is one of the unique elements that makes our collection the fascinating resource it is. The Quercetum, or "collection of oaks," was established in 1953 as the brain child of Doctors Schramm and Schreiner, members of the Arboretum staff.

It was an original idea, and an original name. The purpose was to establish a documented gene pool to further research into the oak genus.

The Quercetum was named for Francois Andre Michaux, a noted French botanist whose special interest was American oaks. Monsieur Michaux endowed the American Philosophical Society with a fund earmarked for research in the fields of forestry and agriculture. It was the Michaux Fund of the American Philosophical Society, in cooperation with the Morris Arboretum and the U. S. Northeastern Forest Service, which helped found the Quercetum.

Forty native oak species and nine varieties were set out as seedlings in 1956. This represented practically all the common oaks of America. Simultaneously, sister collections were established in other institutions around the country. These sister plantings were drawn from the same seed lots as the Morris collection and, as such, provide valuable comparative data.

The collection today consists of 239 trees and represents 20 species of the original forty that have adapted to the Philadelphia climate. The following is a report on the progress of the Quercetum after 16 years of controlled observation. As a catalog of growth rates and hardiness factors, climate and soil influences, it provides not only progress data, but documentation for further scientific study.

S. B. B.

A PROGRESS REPORT

STATUS OF MICHAUX QUERCETUM, 1972

J. J. Willaman, J. Y. Hsiao and H. L. Li

The Michaux Quercetum was established in 1953 to provide materials and facilities for theoretical and applied research on oaks. The general plan and procedure was given in the first report by Schramm and Schreiner (1954). Except for one or two Asiatic species, only American oaks have been included in the Quercetum so far.

From 1953 to 1955, 40 native species and 9 varieties covering practically all of the common oaks in this country were represented in seeds and seedling collections (Li 1955, Fogg 1955, 1956) with a fair representation of each from different localities within its geographical range. Mortality rate of seedlings from milder arcas in the western and southern parts of the country were noted (Li 1955, Santamour 1960). Variations in certain red and white oak species in the juvenile conditions were studied (Santamour & Schreiner 1961 a, b; Gabriel 1958).

Since 1956 young trees have been planted out in a permanent position in the Arboretum. Duplicate collections of most seed lots were established at several places around the country, including Longwood Gardens, Holden Arboretum, Ohio Agricultural Research and Development Center, University of Washington Arborctum, College of William and Mary, University of Wisconsin and others (Li, 1958).

Some of these collections, for various reasons, have not since been maintained. Among the most extensive representations, the plantings at Longwood Gardens, Kennett Square, Pa. and at the Ohio Agricultural Research and Development Center, Wooster, Ohio, have not only been constantly maintained, but records have been made of the growth and behavior of the trees.

The following is a report on the conditions of the Michaux Quercetum as of May 1972. Besides the collection at the Morris Arboretum, the ones at Longwood and Ohio are included for comparativc studies. We are indebted to these two institutions for allowing us to use their valuablc data for this report.

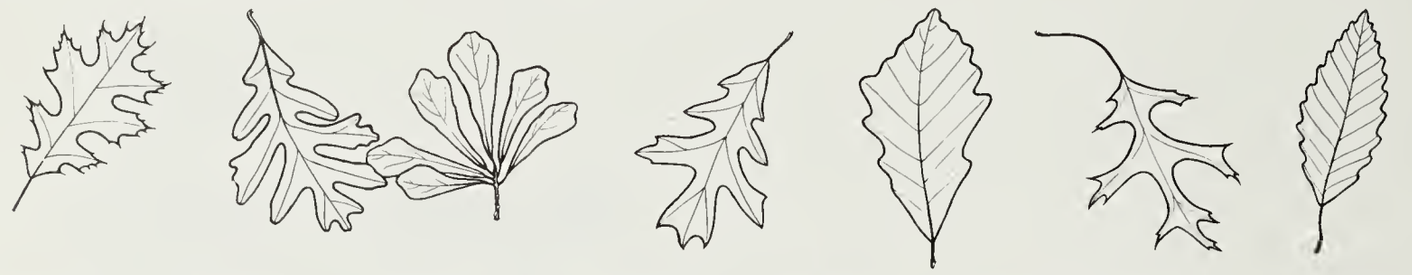
The total number of trees in the Quercetum in May, 1972 was 239. However, only 89 were useful for the present study relating seed lot origin to the growth of oaks. Forty-four trees had multiple trunks, probably due to severe drought conditions during the summer of 1957 and the subsequent severe winter. These conditions had caused a great deal of die-back and the subsequent sprouting of multiple trunks. They could not be used here. Many others looked unhealthy and abnormal and were excludcd. For some 50 the origin of the seed lot had been lost. A few species were not native to the United States. At Longwood Gardens 71 trees were useful and at Wooster, Ohio there were 38.

The secd had been planted in 1953 and 1954, and seedlings had been in their permanent locations for 15 years at the Morris Arboretum, at Longwood Gardens for 10 and at the Research & Development Center at Wooster, Ohio for 14. Table 3 gives the data as of May, 1972: place of origin and hardiness zone of seedlots, the Michaux Quercetum identification number, the height of the tree, the diameter of the trunk, and the yearly increments of these measurements. Height was measured with a ten foot pole stood in the tree, with a probable error of at least $\pm$ 10%. The diameter was taken at 4.5 feet from the ground.

At the Arboretum as reported by Santamour in 1960 practically all of the southern and western species had died. An exception is one specimen of *Q. nuttallii* at the Morris Arboretum and one at Wooster, Ohio. Their measurements are in Table 3.

Comparison of species

One phase of the present status of the trees that may be useful is a comparison among the present species, most of them from the more northern regions, but a few from the south. Following are comments



Q. coccinea Q. alba Q. nigra Q. lyrata Q. bicolor Q. ellipsoidalis Q. prinus

on the comparative sizes and shapes of the existing trees. Ranks of the first three species as to diameter, height and spread, using only those species with six or more specimens, are as follows:

Q. lyrata is the best species—eight usable specimens, no discards, ranks of 1, 5, and 3 in diameter, height and spread. On four of the eight plants leaves were a week or so later than the others in emerging in the spring.

Q. imbricaria shows merit. It ranks second in caliper and in spread, with a height/spread of 1.2.

Q. nigra is consistently broad topped. Of the seven specimens the range of height/spread was only 0.7 to 1.2, and in three specimens dense foliage was noted.

When considering all three dimensions of species having six or more plants, at the end of 15 years growth, the largest are *Q. imbricaria*, *Q. lyrata* and *Q. palustris* and the smallest are *Q. borealis*, *Q. alba*, *Q. falcata* and *Q. phellos*. A summary of the actual situation at the three locations is given in Table 1.

TABLE 1

	Morris Arboretum	Longwood Gardens	Wooster, Ohio
LARGEST	imbricaria	imbricaria	imbricaria
	lyrata	lyrata	velutina
	palustris	shumardii	*
SMALLEST	falcata	borealis	borealis
	phellos	coccinea	alba
	shumardii	nigra	*

Most rapidly growing tree

The most rapidly growing tree in the present group at the Morris Arboretum was seedlot 282, *Q. lyrata* from Mississippi. In 1972, after 15 years in the field, it was 30 feet high and 10.8 inches in diameter. The diameter growth rate was 0.72 inches per year. Perhaps with a little pampering this tree could be induced to attain a full inch per year.

The report on the Quercetum at the end of three years (Santamour and Schreiner, 1961a) contained five of the present species and again *Q. lyrata* was in the lead, with an average height for four plants of 2.7 feet, while *Q. macrocarpa* had 2.5 feet for seven plants.

Shape of the trees

The 1972 data collected at the Morris Arboretum included the approximate spread of the trees. The figures are not included in the table but a few comments may be useful.

The ratio of height/spread was used as an index of the shape of the tree. The eight species involved and their height/spread ratios were *Q. velutina* and *Q. prinus* 1.8; *Q. macrocarpa* and *Q. alba* 1.7; *Q. lyrata* 1.4; *Q. bicolor* 1.3; *Q. imbricaria* 1.2; *Q. nigra* 1.0.

Comparison of growth rates: 3 and 15 years

In the report of Santamour and Schreiner (1961) they discuss the juvenile characters of the species at the Morris Arboretum at three years in the field, including height. The height of the seedlings at three years can be compared to the heights of the same seedlots at 15 years. The species compared by graphs and the number of seedlots in each are *Q. alba* 12, *Q. borealis* 13, *Q. macrocarpa* 6, *Q. prinus* 5, *Q. velutina* 6. In the first four of these there was a tendency for the relative growth rate to be maintained at these two ages, but in *Q. velutina* this relation did not hold.

Growth rate at various localities

In addition to the three localities where the Quercetum seedlots were grown, we can compare certain *species*, but not *seedlots*, with growth at two other locations. Ticknor (1972) records the growth rate of eleven species of oak at the North Willamette Station, Aurora, Oregon, and at Morton Arboretum, Lisle, Ill. His list of oaks includes six of the species in Table 3. The comparison is made in Table 2.

On Table 2 *Q. palustris* appears to be somewhat the fastest grower and *Q. macrocarpa* the slowest, but the differences are slight and could easily be affected by growing conditions. All of these species could be called rather rapidly growing trees.

Q. stellata Q. phellos Q. nuttallii Q. muhlenbergii Q. shumardii Q. falcata Q. macrocarpa

TABLE 2

Average yearly growth in height in feet of six species of oak in five locations, with the years of growth.

Location	Phila., Pa.	Kennett Square,Pa.	Wooster, Ohio	Aurora, Ore.	Lisle, Ill.
Years of growth	15	10	14	5	10
SPECIES					
Q. alba	1.3		0.8		1.6
Q. borealis	1.9	1.6	1.0		1.7
Q. coccinea	1.3	1.5	1.3	3.4	
Q. macrocarpa	1.7	1.3	0.8		1.0
Q. palustris	2.0	1.8		2.9	1.5
Q. phellos	1.5	1.4	1.0	3.1	

Seedlots from various hardiness zones

Santamour and Schreiner (1961a) found a north-south pattern in growth rate of *Q. macrocarpa* in that the northern ones tended for earlier germination, slower height growth and earlier fall coloration. The present data were plotted, using annual rate of growth against the hardiness zone (developed by Arnold Arboretum, cf. *Rehder's Manual*) of the seedlot origins. If, for example, the origin was elose to the edge of zones 8 and 9, the value of 8.5 was assigned for plotting purposes.

Since multiple trunks were probably the result of winter killing of the original trunk, an attempt was made to see whether this was refleeted in the hardiness zones of the seedlots of the affeeted species. The data were plotted and arranged in various ways but no such relation was found. Howevcr, seven of the species were free from multiple trunk specimens. These wcre *Q. borealis*, *Q. coccinea*, *Q. lyrata*, *Q. marilandica*, *Q. palustris*, *Q. shumardii* and *Q. stellata.*

In *Q. macrocarpa* there was a definite trend for faster growth of seedlings as we go from zone 4 to zone 8. This hcld for both diameter and hcight growth, for the trees at Morris Arboretum and Longwood Gardens, and also when thcse were combined. It did not, however, hold for any of the other species that could be used, *Q. alba*, *Q. borealis*, *Q. velutina*, nor when all speeies were used.

Soil pH

The space which was selected for planting out the Quercetum at the Arboretum to its permanent position is a broad strip which runs to the extreme northwestern boundary. During November, 1956 nearly 250 three-year-old oaks were set out (Fogg 1956). Dr. E. T. Wherry was skeptical about its suitability because the area is underlaid with limestone as shown in his 1957 essay on soil rcaction (Wherry 1957). The surface of the site is relatively flat, mineral rich, and circumneutral soils have aceumulated there.

Wherry predicted that only one-fourth of the speeies at most could be expected to reach maturity there. Three-fourths of them, he predicted, eould be expected to become chlorotic and to fall prey to disease in a relatively few years.

A nearly complete set of seedlings was accordingly established at Longwood Gardens and others at a number of other locations. The land at Longwood, largely subacid, low-nutrient loam over sehistose rocks, was considered well suited to the growth of the majority of the oaks (Wherry 1957). The dying-off of evergreen or live oaks from western and southern states in the Michaux Quercetum was considered by Santamour as due to the rigorous winters. Wherry (1972) believes the process was due to soil acidity, that is, the predominantly circumneutral soil.

There is no record of the pH of the Quercetum soil at the time of planting. In 1972, when the present data on the trees were collected after 15 years of growth, the pH at the western, middle and eastern sections was 5.5, 6.0, and 6.0 respectively. Those at three locations in the planting at Longwood Gardens were 5.2, 5.2 and 5.4. The pH at the center at Wooster, Ohio was 6.1.

No chlorosis has so far been reportcd from any of the three areas. Judged by the current measurements of growth rates all three areas are about equally suited for these oak speeies, with the Morris Arboretum possibly being slightly the best. As the trees mature, howcver, and the roots penetrate into the decpcr substrata, the picture may change.

Q. ilicifolia | Q. velutina | Q. imbricaria | Q. borealis | Q. marilandica | Q. palustris

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Illustrations

The oak leaf figures accompanying this article illustrate one of each species represented in the Quercetum (1/5 natural size). Illustrations by Susan B. Blum.

Table 3. Comparison of measurements and annual growth rates of sister seed lot trees of the Miehaux Quereetum eolleetion growing in three loeations. Age of trees: Morris Arboretum (MA), 15; Longwood Gardens (LG) 10; Center at Wooster, Ohio (WO), 14.

SPECIES ORIGIN	HARDINESS ZONE	MQ NO.	HEIGHT in feet (feet per year) MA	LG	WO	DIAMETER in inches (inches per year) MA	LG	WO
			Quercus alba WHITE OAK					
Tex.	8.5	9	22 (1.5)			5.3 (0.35)		
Tex.	8.5	12	12 (0.8)			2.6 (0.17)		
Md.	6	32	22 (1.5)			4.0 (0.27)		
Md.	7	34	20 (1.3)			4.8 (0.32)		
Mass.	4.5	174	20 (1.3)			4.6 (0.31)		
Tenn.	7	213	25 (1.6)			5.6 (0.37)		
Ark.	7	263	25 (1.6)			5.1 (0.34)		
Pa.	5	400	24 (1.6)		12 (0.8)	4.2 (0.28)		3.8 (0.27)
Pa.	5	442	23 (1.5)		12 (0.8)	5.1 (0.34)		2.3 (0.17)
N.J.	6	520	18 (1.2)			3.5 (0.23)		
Va.	8	535	17 (1.2)		13 (0.9)	4.5 (0.30)		3.3 (0.24)
Pa.	5	540			6 (0.4)			1.0 (0.07)
N.Y.	4	567	14 (0.9)			1.6 (0.11)		
N.Y.	4	568			10.4 (0.7)			1.8 (0.12)
Md.	7	575	18 (1.2)			3.8 (0.26)		
Md.	7	603	18 (1.2)			3.8 (0.26)		
Wis.	4	754	19 (1.3)			4.7 (0.31)		
Ill.		757	14 (0.9)			2.9 (0.19)		
			Q. bicolor SWAMP WHITE OAK					
Mich.	4	362	23 (1.6)			5.5 (0.37)		
Ill.	6	427	21 (1.4)			5.8 (0.39)		
			Q. borealis (Q. rubra) RED OAK					
N.H.	3.5	17		15 (1.5)			1.2 (0.12)	
N.H.	3.5	18	24 (1.6)	19 (1.9)	17 (1.2)	4.2 (0.28)	2.7 (0.27)	4.7 (0.34)
N.H.	3.5	19		18 (1.8)			2.2 (0.22)	
N.H.	3.5	20	30 (2.0)	14 (1.5)		3.8 (0.26)	1.3 (0.13)	
Kan.	4	52		15 (1.5)			2.2 (0.22)	
Kan.	4	58		15 (1.5)			1.6 (0.16)	
Mass.	6	176	30 (2.0)			5.1 (0.34)		
Mass.	6	177			15 (1.1)			2.6 (0.19)
N.Car.	6.5	209	24 (1.6)	15 (1.5)		3.7 (0.25)	1.8 (0.18)	
N.Car.	6.5	210	35 (2.4)	16 (1.6)		6.4 (0.43)	1.7 (0.17)	
N.Car.	6.5	211	35 (2.4)			6.7 (0.45)		
N.Car.	6.5	212	17 (1.1)	15 (1.5)	17 (1.2)	2.0 (0.13)	1.6 (0.16)	4.2 (0.30)
N.J.	6	221	34 (2.3)			6.4 (0.43)		
Minn.	3.5	359			7 (0.5)			1.0 (0.07)
Mich.	4	365	32 (2.2)			4.8 (0.32)		
Pa.	6	376	22 (1.5)		14 (1.0)	4.8 (0.32)		2.8 (0.20)
Pa.	6	377	20 (1.4)		13 (1.0)	3.5 (0.24)		2.5 (0.18)
Ill.	5.5	416		15 (1.5)			1.8 (0.18)	
Ill.	5	418	27 (1.8)		14 (1.0)	5.3 (0.35)		3.8 (0.27)
Ill.	6	426	29 (2.0)	17 (1.7)		5.2 (0.35)	2.2 (0.22)	
Ill.	6	471	22 (1.5)	17 (1.7)	17 (1.2)	4.2 (0.28)	2.1 (0.21)	4.1 (0.30)
N.H.	3.5	532			9 (0.6)			1.3 (0.10)
Ill.	5.5	545	32 (2.1)			5.1 (0.34)		
Mass.	4	555	20 (1.3)			3.5 (0.23)		
N.Y.	4	566			10 (0.7)			1.5 (0.12)
			Q. coccinea SCARLET OAK					
Va.	7	108	26 (1.6)	16 (1.6)	18 (1.3)	3.5 (0.24)	2.0 (0.20)	3.7 (0.27)
Tenn.	6.5	231		13 (1.3)			1.5 (0.15)	
Tenn.	6.5	232	26 (1.6)	15 (1.5)		3.7 (0.26)	1.8 (0.18)	
Ala.	8	289		15 (1.5)			1.7 (0.17)	
Ala.	8	293	10 (0.7)	15 (1.5)		1.3 (0.09)	1.8 (0.18)	
Ill.	6	470		16 (1.6)			1.1 (0.11)	
Ill	6	550		12 (1.2)			1.1 (0.11)	
			Q. ellipsoidalis YELLOW OAK					
Minn.	3.5	119	16 (1.1)			4.8 (0.34)		
			Q. falcata SPANISH OAK					
Ala.	8	292		14 (1.4)			1.6 (0.16)	
Ark.	8	298		16 (1.6)			2.4 (0.24)	
Ill.	6	378	22 (1.6)			35 (0.25)		
Va.	8	409		13 (1.3)			1.6 (0.16)	
Va.	8	410	24 (1.7)	14 (1.4)		4.2 (0.29)	1.9 (0.19)	
Va.	8	412	18 (1.3)	17 (1.7)		4.8 (0.32)	2.3 (0.23)	
Md.	8	582		13 (1.3)			1.5 (0.15)	
			Q. dicifolia SCRUB OAK					
Pa.	5	445			8 (0.6)			1.3 (0.9)
			Q imbricaria SHINGLE OAK					
Ohio	4	350	23 (1.5)	15 (1.5)	17 (1.3)	6.5 (0.44)	1.9 (0.19)	3.2 (0.24)
Ohio	4	351	20 (1.4)	15 (1.5)	13 (0.9)	5.4 (0.36)	2.1 (0.21)	2.8 (0.20)
Ill.	5.5	417		16 (1.6)	17 (1.2)		2.2 (0.22)	4.5 (0.33)
Ind.	6	462	24 (1.6)	14 (1.4)		5.1 (0.34)	1.7 (0.17)	
			Q. lyrata OVERCUP OAK					
Tex.	9	15	27 (1.3)		14 (1.0)	7.2 (0.48)		4.5 (0.33)
Miss.	7.5	282	30 (2.0			10.8 (0.72)		
Miss.	7.5	283	21 (1.4)		12 (0.9)	5.8 (0.39)		3.2 (0.24)
Ark.	8	295	23 (1.5)		9 (0.7)	5.1 (0.34)		1.3 (0.10)

SPECIES ORIGIN	HARDINESS ZONE	MQ NO.	HEIGHT in feet (feet per year) MA	LG	WO	DIAMETER in inches (inches per year) MA	LG	WO
			Q. macrocarpa BUR OAK					
Kan.	4.5	53	31 (2.1)	17 (1.7)		6.2 (0.41)	3.2 (0.32)	
S.Dak.	4	185	20 (1.3)	13 (1.3)	11 (0.8)	3.2 (0.22)	1.5 (0.15)	2.1 (0.16)
S.Dak.	4	186	15 (1.0)	13 (1.3)		2.6 (0.17)	1.5 (0.15)	
Minn.	2.5	355	22 (1.5)	11 (1.1)		3.5 (0.23)	0.9 (0.09)	
Kan.	4	402	35 (2.3)	11 (1.1)		6.4 (0.43)	2.6 (0.26)	
Ill.		543	22 (1.5)			5.4 (0.36)		
			Q. marilandica BLACK JACK OAK					
Tex.	8.5	16		9 (0.9)			0.9 (0.09)	
Kan.	4	57		10 (1.0)			1.3 (0.13)	
N.J.	6	227		10 (1.0)			0.6 (0.06)	
Ark.	8	299		9 (0.9)			1.0 (0.10)	
			Q. muhlenbergii YELLOW CHESTNUT OAK					
Va.	7	110	21 (1.4)			4.5 (0.30)		
			Q. nigra WATER OAK					
Md.	7	31	23 (1.5)	14 (1.4)		5.6 (0.37)	1.8 (0.18)	
Md.	7	33	20 (1.3)	18 (1.8)		5.9 (0.39)	1.8 (0.18)	
Miss.	7.5	286		13 (1.3)			1.5 (0.15)	
Ark.	8	299A	36 (2.4)	15 (1.5)		6.7 (0.45)	2.1 (0.21)	
Va.	8	408	11 (0.8)	15 (1.5)		2.6 (0.17)	1.8 (0.18)	
Va.	8	414	12 (0.8)	13 (1.3)		4.2 (0.28)	1.6 (0.16)	
			Q. nuttallii					
Miss.	7.5	287	11 (0.7)		12 (0.8)	2.9 (0.19)		2.3 (0.15)
			Q. palustris PIN OAK					
Ohio	5	343	35 (2.3)			6.4 (0.43)		
Ohio	5	348	27 (1.8)	19 (1.9)		4.7 (0.31)	3.6 (0.36)	
Ohio	5	349	26 (1.7)	18 (1.8)		4.2 (0.28)	2.6 (0.26)	
Ill.	5	424	32 (2.2)	18 (1.8)		6.7 (0.45)	2.8 (0.28)	
			Q. phellos WILLOW OAK					
Miss.	7	285		13 (1.3)			2.0 (0.20)	
Ark.	8	297	18 (1.2)	14 (1.4)		4.2 (0.28)	1.9 (0.19)	
Va.	8	411		13 (1.3)			1.9 (0.19)	
Va.	8	413	25 (1.7)	16 (1.6)	14 (1.0)	5.8 (0.39)	2.3 (0.23)	3.9 (0.29)
Md.	7	576		14 (1.4)			2.5 (0.25)	
Md.	7	584		15 (1.5)			2.2 (0.22)	
			Q. prinus CHESTNUT OAK					
Va.	7	109	32 (2.2)			5.7 (0.38)		
Conn.	5	190	32 (2.2)			6.4 (0.43)		
Ohio	4.5	352	23 (1.5)			4.5 (0.30)		
Ohio	4.5	353	28 (1.9)			6.7 (0.45)		
Pa.	6	539	15 (1.0)			2.9 (0.19)		
			Q. shumardii SHUMARD OAK					
Tenn.	6	214	20 (1.3)	16 (1.6)	14 (1.0)	3.8 (0.25)	2.4 (1.24)	2.7 (0.20)
Tenn.	6	215		18 (1.8)	15 (1.0)		2.4 (0.24)	3.2 (0.24)
Miss.	7.5	284		19 (1.9)	14 (1.0)		2.6 (0.26)	2.4 (0.18)
Fla.	9	332	16 (1.1)	15 (1.5)		2.2 (0.15)	1.7 (0.17)	
Ill.	5	420	22 (1.5)	18 (1.8)	15 (1.1)	4.3 (0.29)	2.5 (0.25)	4.1 (0.28)
			Q. stellata POST OAK					
Tenn.	7	229	17 (1.1)			3.8 (0.25)		
Tenn.	7	230	24 (1.6)			4.8 (0.32)		
Mo.	6	474		13 (1.4)			1.0 (0.10)	
Mo.	6	475	12 (0.9)			2.9 (0.19)		
Md.	7.5	581	19 (1.3)	12 (1.2)		3.7 (0.25)	1.1 (0.11)	
			Q. velutina BLACK OAK					
Va.	7	107	30 (2.0)	14 (1.4)		6.4 (0.43)	1.6 (0.16)	
Conn.	5	192	20 (1.4)			2.9 (0.19)		
Tenn.	6.5	233		15 (1.5)			2.0 (0.20)	
Tenn.	6.5	234	25 (1.7)	15 (1.5)	18 (1.3)	4.2 (0.28)	1.9 (0.19)	3.6 (0.26)
Ark.	7	264	30 (2.0)			6.7 (0.45)		
Ala.	8	290		18 (1.8)			1.8 (0.18)	
Ala.	8	291	19 (1.3)	15 (1.5)		2.3 (0.15)	1.7 (0.17)	
Mich.	4	366	30 (2.0)	16 (1.6)	16 (1.2)	6.5 (0.43)	1.9 (0.19)	3.1 (0.23)
N.Car.	7	372		16 (1.6)			2.2 (0.22)	
Ill.	4.5	379		17 (1.7)			2.1 (0.21)	
Ill.	5	422		16 (1.6)	15 (1.1)		1.8 (0.18)	3.1 (0.23)
Ill.	6	425	24 (1.6)	14 (1.4)		4.3 (0.29)	1.7 (0.17)	
Ill.	6	428	20 (1.4)	16 (1.6)	16 (1.1)	2.6 (0.17)	1.9 (0.19)	3.6 (0.26)
Mo.	6	472	22 (1.5)			3.8 (0.25)		
Ill.	5	756	20 (1.4)			3.5 (0.24)		

shrub profiles

Shrubs come in a great variety of habits and adaptations, a great variety of sizes from ground covers to towering growths, exhibit showy floral displays or plainly frame or accent other ornamentals. They adapt to any gardener's desired end, and then, with a few snips of the trimming shears, allow him to change his mind.

But of all the types of plants available to the gardener to utilize, the shrub is perhaps the most over-looked. With this in mind, the Bulletin *is instituting a series of Shrub Profiles.*

Trees are a permanent part of the landscape, whether pre-established or planted by the gardener. Trees dominate large areas, are not easily moved, and are usually an immutable around which the rest of a garden is planned.

Herbaceous plants, annual or perennial, are the most prolific and adaptable of the garden scene. They come in infinite variety and are easily changed according to a gardener's whims and changing moods.

But shrubs are a middle ground, and that is more than a topographical description. More permanent than our herbaceous flowering plants, less so than our trees, a shrub can remain forever where it's first planted, or can be moved or replaced with far less agony than can a tree.

As with many things in our technological society, shrub use has tended to become stereotyped. The number of shrubs utilized in gardens and landscape plantings compared with the number and rich variety available, especially among the introduced species, indicates a great gap in our knowledge.

Each issue we will try to fill that gap with a shrub or two from the notable Morris collection.

S.B.B.

SECURINEGA SUFFRUTICOSA

by Hui-Lin Li

Although *Securinega suffruticosa* has been introduced into western gardens since the eighteenth century and planted for its bright green leaves, it is today one of the least known shrubs cultivated in eastern North America. This shrub is a native of Asia, growing from northeastern Asia to central China.

Securinega is a deciduous shrub. It grows to a height of six to seven feet, often with a single trunk and a much-branched crown. The slender green hairless branches are spreading and more or less drooping. The bright yellowish-green leaves are small, about one to two inches long, and ovate-shaped with entire margins. They are alternately arranged on the stem. The general appearance of the plant is somewhat like a bushy willow.

The plant has separate male and female flowers, borne either on the same or on separate trees. Small greenish white flowers bloom July to August clustered in the axils of leaves. Male and female flowers are clustered separately, the male groupings being slightly greater in number than the female.

The fruit is a small rounded capsule about one-fifth of an inch across. When the fruit is ripe in September to October, it explodes, scattering the three to six small brownish seeds often to a distance of several feet.

Securinega suffruticosa is a plant of some botanical interest. It is the only woody species of the large and widespread Spurge Family, Euphorbiaceae, that is hardy in northeastern North America from Philadelphia to Boston. The family includes such common weeds as the different spurges (*Euphorbia* spp.), but is primarily a tropical one. Very few of its woody species grow even in mild temperate climates. *Securinega* is a genus with about ten species in temperate and subtropical regions of Central and South America, Asia, southern Europe, and Africa, but only one species, *S. suffruticosa*, is hardy in colder climates.

The plant does not have showy flowers, but the spreading habit together with the bright green foliage

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are of some ornamental value. In its native habit it grows gregariously in dry, sunny locations. *Securinega* will grow in any soil, and is especially recommended for use in steeply sloping, exposed situations where many other plants are not adaptable. It is readily propagated from seed.

This shrub yields an alkaloid, Securinine, which has been used clinically in the Soviet Union for the last twelve years and more recently in China. This alkaloid, a powerful stimulant of the central nervous system, has been used by American scientists in the treatment of certain neuro-muscular disorders. Securinine may prove to be an unusual and potentially useful drug for the medical world. (1, 2).

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H. L. Li

Five Early Botanists

by Alfred E. Schuyler

This article originated as a talk by Dr. Schuyler to the Philadelphia Botanical Club at their January, 1973, meeting. Dr. Schuyler holds the Bayard Long Chair of Botany at the Academy of Natural Sciences, and is a Research Associate with the Morris Arboretum.

From the liberty bell to the first engine and ladder company, Philadelphia has been an historical point of reference for the rest of the nation. Through the researches of five early botanists and the maintenance of their valuable specimen collections, Philadelphia has achieved historical significance in the botanical field as well.

These five botanists, Henry Muhlenberg, Frederick Pursh, Thomas Nuttall, Lewis von Schweinitz and Constantine Rafinesque, working in the late eighteenth and early nineteenth centuries, contributed invaluable research into the flora of North America. Their specimens remain among us in the herbarium collections of the Academy of Natural Sciences. And though these men are not the only botanists of that early American period, nor are their collections the only significant ones of the Academy herbarium, the work and collections of these five botanists form a prototype for much of the botanic and taxonomic efforts that have followed.

These early researchers were working in a partially explored country (the Lewis and Clark Expedition did not traverse our country until 1806) in a field just opening up to organized scientific inquiry in the New World. Their plant collecting expeditions took them to sparsely settled and sometimes virgin areas of the country. And when they had finally compiled their data, publication was often a problem in a politically-torn young country.

The priceless resource their collections provide can be further appreciated by an understanding of the procedures of plant naming.

According to the International Code of Botanical Nomenclature, the first name given to a flowering plant species, beginning with Linnaeus' *Species Plantarum* in 1753, is the name by which the plant will always be known unless rule violations prohibit its use. This major principle of plant nomenclature—*priority of publication*—requires botanists to search eighteenth and nineteenth century literature to determine the earliest names published for plants. Then the taxonomist must find the **specific specimens** upon which the author of the name based his description. These specimens, referred to as *types*, are essential for determining the exact identity of the organism to which the name is applied. It is this major principle of plant nomenclature—*the type method*—that requires botanists to examine eighteenth and nineteenth century botanical collections if they are to be certain they are using the proper plant names.

The five investigators under discussion were very different types of men, and their differences influenced their nature as botanists and the kinds of contributions they made to botanical research. The studious clergymen, interested in the preservation and extension of knowledge; the insatiable wanderer; the dilettante—or Renaissance man, depending on who is telling the tale; these gentlemen form a cross section of approaches. Each we will treat separately—and without further ado.

FRUSTANEA.

Calix.	*Corolla.*				*Habitat. Fructus, et Tempus florendi.*
simpl.	radiat. 586.	ACMELLA		ACMELLA	recept. paleac. papp. 2 setosus.
	lut.	repens, (Spilanthus repens Mx.)		creeping	Car.
imbr.	radiat. 587.	HELIOPSIS Pers.		OX-EYE	recept. paleac.
	lut.	lævis Pers. 2 / Buphthalmum helianthoides L.			Pens. fl. Jul. Car. Virg.
imbr.	radiat. 588.	BUPHTHALMUM		OXE-EYE	recept. paleac. convex.
	lut.	frutescens	♄	shrubby	Virg. Car.

FRUSTANEA.

imbr.	radiat. 589.	HELIANTHUS			SUNFLOWER	recept. paleac. planum papp. 2 phyllus.
	lut.	1. multiflorus	2		many-flowered	Virg. Pens H. fl. Aug.
	lut.	2. tuberosus	2		Jerusalem artichoke	Pens. fl. Sept. Virg.
	lut.	3. pubescens	2	♂	hairy	Illin. Ten. Pens. H. fl. Sept.
	lut.	4 mollis	2		soft	Pens. fl. Jul.
	lut.	5. trachelifolius	2		throatwort-leaved	Pens. fl. Aug.
	lut.	6. decapetalus	2		ten-petalled	Pens. fl. Aug.
	lut.	7. frondosus	2		leafy	Pens. fl. Jul.
		8. strumosus	2		carrot-rooted	fl. Sept.
		9. prostratus	2		prostrate	
	lut.	10. giganteus	2		gigantic	Virg. Car. fl. Sept.
	lut.	11. altissimus	2		tall	Pens. fl. Aug.
	lut.	12. angustifolius	2		narrow-leaved	Car. Virg. fl. Sept.
	lut.	13. divaricatus	2		rough-leaved	Pens. fl. Aug. Virg. Car.
	lut.	14. lætiflorus	2		long-flowered	
	lut.	15. atrorubens	2		dark-red	Penns. Carol Virg. fl. Jul. Sept.
	lut.	16. annuus C.	☉		annual	Pens. H. fl. Jun.—Oct.
		17. macrophyllos Willd.	2		large-leaved	
imbr.	radiat. 590.	GALARDIA			GALARDIA	recept. paleac. hemisphær. pappus palaceus polyphyll.
	lut.	1. bicolor			two-coloured	Car.

Muhlenberg evolved his own method of cataloging flora. Above is an excerpt from his Catalogus Plantarum Americae Septentrionalis. *This columnar breakdown was distinctly Muhlenberg's and bears some explaining. Column 1 lists the character of the sepals, Column 2, the character of the petals. Column 3 is the Latin name of the plant. Column 4 is the English translation of the Latin name or, in some instances, the vulgar name. The figures inserted between Columns 3 and 4 are signs of duration: ☉ indicates an annual, ♂, a biennial, 2, an herbaceous perennial, ♄, a tree or shrub. Column 5 lists the plant's habitat by state (Pennsylvania, Virginia, etc.), plus periods of both flowering and fruiting.*

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Child of the patriarch of the Lutheran Church in North America son Muhlenberg also became a cleric, but with a fundamental difference —he was also a botanist.

Henry Ernest Muhlenberg was born in 1753, the year Linnaeus' *Species Plantarum* was published. It was obviously a good year for botany. Muhlenberg's work earned him the title, "Father of North American Botany," a tribute bestowed by the eminent botanist, John Torrey.

Child of the patriarch of the Lutheran Church in North America, Henry Melchior Muhlenberg, son Henry was apparently cut from the same cloth as his father. He too became a cleric but with a fundamental difference—he was also a botanist.

Muhlenberg was educated in Germany with his two older brothers. Upon his return to this continent he found Philadelphia occupied by the British, and the country in the throes of the Revolutionary War. The political situation interrupted his career, and it was during this time, when he had few responsibilities as a clergyman, that he was free to develop his interest in botany.

In 1780 Muhlenberg received a call to pastor the congregation of Trinity Lutheran Church in Lancaster, Pennsylvania, where he remained for the rest of his life. Here he gained worldwide recognition as a botanist while also becoming the president of what is today Franklin and Marshall College. His botanical reputation attracted the eminent naturalists Aime Bonpland and Alexander von Humboldt, who visited him on their return trip to Europe from South America. He exchanged specimens with such well-known European botanists as Schreber, Schkur, and Willdenow, and the American botanist, Stephen Elliott.

Muhlenberg's two major works, *Catalogus Plantarum Americae Septentrionalis*.....(1813) and *Descriptio uberior Plantarum Graminum et Plantarum Calamarium Americae Septentrionalis* (1817) (roughly translated, Catalog of the Plants of North America, and A Full Description of the Grasses and Reeds of North America) were published two years prior and two years after his death respectively. The *Catalogus* was the first attempt to treat the flora of North America by a resident botanist whose major collections *remained* in North America. A major problem facing Muhlenberg was the inordinate length of time it took to get his manuscripts printed, and one wonders how much he would have published without such a handicap.

Among the nearly 4,000 specimens in the Muhlenberg herbarium at the Academy of Natural Sciences are many *types* of names published by Muhlenberg, as well as *types* of names published by botanists with whom he exchanged specimens.

Pursh was the last major botanist of the Colonial Period. His *Flora* was published in England during the War of 1812. It must have been a bitter pill for many Americans to swallow to have a major botanical work with descriptions of new species gleaned from a landmark American expedition published in the country of "the enemy." But, political considerations aside, publication was of overriding importance for the overall benefit of botany and for proper recognition of the botanical significance of the Lewis and Clark Expedition.

It is possible that having a major American flora published in a politically hostile country caused American botanists to make more serious efforts to get their works published in America. At any rate, the difficult problems with American printers that Muhlenberg had faced were overcome by subsequent botanists involved with publication of North American flora.

Frederick Pursh came to the United States from Germany in 1799 at the age of 25 and eventually became a gardener on William Hamilton's estate "Woodlands"—now a cemetery in West Philadelphia near the University of Pennsylvania. Apparently his work on Hamilton's garden was widely appreciated and he attracted the attention and patronage of Benjamin Smith Barton, Professor of Materica Medica, Natural History and Botany at the University of Pennsylvania, who provided support for Pursh's collecting trips in eastern North America in 1806 and 1807.

Upon his return from the 1807 trip, Pursh worked with the botanical specimens brought back from the Lewis and Clark Expedition. When he went to England in the winter of 1811-12, Pursh had comprehensive notes, drawings, and fragments or duplicates of these specimens. Here, with the patronage and hospitality of Sir Aylmer Bourke Lambert, he did his classic work, *Flora Americae Septentrionalis*, (Flora of North America), which described and illustrated many new species based on the specimens from the Lewis and Clark Expedition. These specimens remained in Lambert's possession until his death in 1842. Fortunately for American botany, Edward Tuckerman, then president of Amherst College, was in London during the auction of Lambert's herbarium and he purchased the Lewis and Clark specimens as well as other North American specimens in the collection. Tuckerman donated these specimens to the Academy where they are housed today along with those Lewis and Clark specimens which stayed in Philadelphia.

Plate from Pursh's *Flora Americae Septentrionalis,* 1814.

"[Pursh's] Flora *was published in England during the War of 1812. It must have been a bitter pill for many Americans to swallow to have a major botanical work with descriptions of new species gleaned from a landmark American expedition published in the country of 'the enemy'."*

"In 1836 Nuttall sailed on the Alert *from San Diego to Boston. This trip led to his appearance in R. H. Dana's* Two Years before the Mast *as 'Old Curious'—an apt title for so restless a researcher."*

Thomas Nuttall, son of an English printer, is thought to have worked in a printing shop when he arrived in Philadelphia in 1808 at the age of 22. His curiosity about the identity of a plant led him to Benjamin Smith Barton (the same as mentioned above), who appreciated and encouraged the young man's interest in botany. Eventually Barton financed collecting trips for Nuttall as he had done for Pursh.

Barton was a naturalist of broad interests and ambitions. But at the time of his meeting with Nuttall his physical health was poor. In Nuttall, Barton found a mind eager for knowledge and a strong young body that could withstand the rigors of extensive collecting expeditions. An alliance was formed which served the needs of both men. But with or without Barton's sponsorship, Nuttall was to establish a pattern of travel rivalled by few.

In 1810 Nuttall was sent by Barton on an ambitious two year trip which took him by stage, foot, and canoe to the Strait of Mackinac on Lake Michigan. Here Nuttall made contact with an expedition of the Pacific Fur Company bound for the mouth of the Columbia River. Their purpose was to found a fur trading depot, later called Astoria. Nuttall made arrangements to accompany this party up the Missouri River from St. Louis in 1811.

From this expedition comes a reference to Nuttall in Washington Irving's *Astoria*. The Canadian boatmen dubbed Nuttall "le fou" ("the fool")—an epithet reflecting the inconvenience they suffered waiting for Nuttall to collect his plants.

Nuttall ascended the Missouri into what is now North Dakota, then returned to St. Louis and finally arrived in New Orleans late in 1811. He went to England during the War of 1812, and returned to North America in 1815. After collecting in the southern United States, Nuttall published his major botanical work, *The Genera of North American Plants, and Catalogue of the Species to the Year 1817*, in 1818.

Nuttall continued his travels variously in the Arkansas Territory, New England and the southern states. He revisited England in 1824, returned to the United States in 1825 and accepted a post as Lecturer on Natural History and Curator of the Botanical Garden at Harvard University. In 1834 he resigned this position to join Captain Nathaniel Wyeth on Wyeth's second transcontinental expedition. Upon reaching the far coast, Nuttall, ever onward, sailed to the Hawaiian Islands where he spent two winters.

In 1836 Nuttall sailed on the *Alert* from San Diego to Boston. This trip led to his appearance in R. H. Dana's *Two Years before the Mast* as "Old Curious"—an apt title for so restless a researcher. It was this voyage that signaled the end of his extensive botanical travels.

Because of a residence requirement in a will which would establish his financial security, Nuttall made his home in England from 1842 until his death in 1859. Nuttall was a member of the Academy of Natural Sciences, and his specimens collected before 1818 can be found in the Academy herbarium; the major portion of those collected at a later date were donated to the British Museum upon Nuttall's death.

"The large herbarium von Schweinitz accumulated is extremely valuable not only because of his own personal collections but because of material he obtained from other botanists."

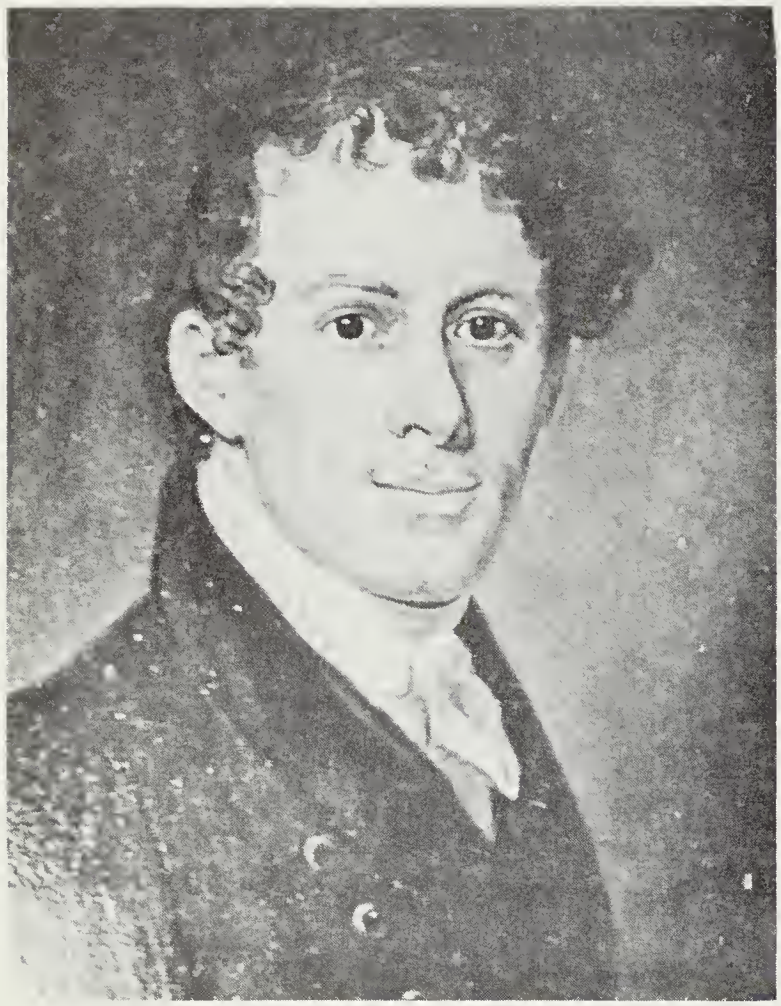
Lewis David von Schweinitz, was born in Bethlehem, Pennsylvania in 1780. He not only had a distinguished Moravian ancestry, but became a Moravian minister himself. He moved to Germany with his family in 1798, where he worked with Johannes Baptista von Albertini and together they published accounts of new species of fungi. In 1812, at the age of 32, von Schweinitz was appointed to a church position in Salem, North Carolina. Here he continued his work with fungi and in 1818, published his *Synopsis Fungorum Carolinae superious* (Synopsis of the Fungi of North Carolina).

In 1821, von Schweinitz moved back to Bethlehem, Pa., where he became Proprietor of the Moravian Church Estates in the North. He continued his botanical endeavors and, despite the added burden of official duties and ill health, published his *magnum opus, Synopsis Fungorum in America Boreali media degentium* (Synopsis of the Fungi of North America) in 1832, only two years before his death. Von Schweinitz made substantial contributions in other plant groups as well as fungi by publishing monographs on violets and on the sedge genus *Carex*, (the largest genus of flowering plants in North America).

The large herbarium von Schweinitz accumulated is extremely valuable not only because of his own personal collections but because of material he obtained from other botanists. From the old world there are collections of Hooker (Europe), Ledebour (Central Asia), Leitner (South Africa), Sprengel (Germany), and Wallich (India); from North America there are those of Baldwin, Nuttall and Rafinesque; and from South America those of Martius (Brazil). This rich collection, estimated to contain about 23,000 plant species, dwarfed previous collections when it came to the Academy after von Schweinitz's death in 1834.

Constantine Samuel Rafinesque, perhaps the most colorful nineteenth century North American botanist, spent his youth in France and Italy. He first came to Philadelphia in 1802 at the age of 19, and keenly pursued his interests in natural history. But it was not until 1815 that Rafinesque became a permanent resident of North America. From 1819 to 1826 he was Professor of Botany, Natural History, and Modern Languages at Transylvania University in Lexington, Kentucky, and from 1826 until his death in 1830 he resided in Philadelphia.

The ambitious Rafinesque had about 1,000 publications and proposed about 6,700 new names of plant species. His *Florula Ludoviciana* (Small Flora of Louisiana) (1817) is one of the most unique—and most controversial—works ever published. Here Rafinesque applied names to descriptions of plants



"Rafinesque proposed more generic names of plants that have ever been proposed by any botanist, and this despite the fact that he was active in zoology, medicine, geology, archeology, philology, and economics."

which the Frenchman C. C. Robin had previously published in a work about his travels near the Gulf Coast between 1802 and 1806. This flora *in absentia*, which contained many new plant names, was criticized severely by Asa Gray who regarded the Rafinesque names as, ".....fictitious, and unworthy of the slightest notice."

Nowadays botanists are giving notice to Rafinesque names published in *Florula Ludoviciana*, and many of them have been adopted for plants of southeastern United States. Other major works of Rafinesque were his *Medical Flora* (vol. 1, 1828; vol. 2, 1830) and his *New Flora and Botany of North America* (1836-1838).

Rafinesque's extensive travels throughout eastern North America made him very knowledgeable of the North American flora, but he used poor judgment in publishing this knowledge. His zeal for publication is evident when, in 1819, the editor of the American Journal of Science returned his manuscripts—partly because their length would have excluded the publication of any other material in his journal.

Rafinesque proposed more generic names of plants than have ever been proposed by any botanist, and this despite the fact that he was active in zoology, medicine, geology, archeology, philology, and economics. His regrettably sketchy and poorly prepared published works have prevented a very high proportion of his published names from being adopted. Rafinesque names are even more difficult to apply because of the lack of specimens to document them. Most of Rafinesque's herbarium of an estimated 50,000 specimens is no longer extant. The Academy herbarium contains a few hundred Rafinesque specimens of which about fifty are probable *types*.

The works of these five botanists were foundation blocks for the botany of our new continent. Their plant collections are still referred to, are still necessary to all who pursue plant science today. The Academy of Natural Sciences, in collecting and preserving this landmark material, has made Philadelphia a focal point for all investigators of North American flora.

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books

ALASKA TREES AND SHRUBS by Leslie A. Viereck and Elbert L. Little, Jr. Forest Service, United States Department of Agriculture. 1972. 265 pp. $3.25.

This very well-organized account of some 133 species of woody plants native to the 49th state clearly deserves wide-spread dissemination. It fills a lack left by an earlier work, Taylor and Little's "Pocket Guide to Alaska Trees," 1950, which did not include a treatment of shrubby species.

In the publication here reviewed the authors, quite clearly on the basis of thorough field, herbarium and library researches, have provided a valuable and generous compilation of information on nomenclature, vegetative-floral-fruit characters, occurrence, and geographic distribution for each of the 133 species. A small distribution map of Alaska, adapted from the well-known investigations made by Hulten, is included for each species. Where relevant, informative comments on the human and animal ecology of a species form part of the individual descriptions.

In perusing this book, one learns that the population of 133 species represents 19 different plant families. The chief families, ranked in order of prominence, are the Willow (*Salicaceae*), Heath (*Ericaceae*), Rose (*Rosaceae*), Pine (*Pinaceae*), Gooseberry (*Grossulariaceae*), and Honeysuckle (*Caprifoliaceae*) families. The Willow, Heath, and Rose families account for about two-thirds of the native woody species.

It is of interest to note that the following Asian-Siberian species have their sole natural habitat in North America in western Alaska: *Rhododendron camtschaticum*, Siberian Wedgeleaf Willow (*Salix sphenophylla*), Siberian Mountain Ash (*Sorbus sambucifolia*), and Japanese Wintergreen (*Gaultheria miqueliana*). Circumpolar heaths such as the arctic-alpine Alpine Azalea (*Loiseleuria procumbens*) and Lapland Rosebay (*Rhododendron lapponicum*) occur throughout a good portion of Alaska.

The main types of vegetation, e.g. coastal forest, treeless bogs, tundra, etc., are briefly described. Four separate, fairly simple keys are provided for aid in the identification of plant material either in winter or in summer conditions.

The inclusion of illustrations for each species in this relatively compact handbook is particularly helpful for the non-specialist. Many of the figures are original, others have been judiciously selected from various published sources. For the person sensitive to botanical illustration, the figures provide an interesting range of black and white, line and stipple techniques.

A folded map of Alaska (Scale 1:5,000,000), printed in color, depicts in detail the location of the eight main vegetation types.

This excellent handbook should prove highly useful not only to residents of Alaska and northwestern Canada but also to those having interest in the woody plants of northern regions. The publication is available from the Superintendent of Documents, U. S. Government Printing Office, Washington, D.C. 10402 at the astonishingly low price of $3.25.

A. Orville Dahl

GREENHOUSE GARDENING by G. F. Gardiner. Chemical Publishing Co. Inc. New York. 1968. $7.50.

G. F. Gardiner was the former curator of the botanic gardens and a recognized teacher of gardening at the University of Bristol. Since his retirement, he has published two works, *Pictorial Plant Propagation* and *Modern Indoor Gardening.*

Mr. Gardiner has written this book for those people who desire to grow plants that provide flowers for the greenhouse or conservatory. His approach is fundemental and he has set rigid guide lines for the topics to be covered. The subject matter is direct and to the point. But for many amateur gardeners I believe that a few very important details are missing.

The basic discussion of the text deals with four subject areas; physical facilities, greenhouse management, plant propagation and cultural tips on selected plant species. Under the discussion of physical facilities, Mr. Gardiner leaves the amateur gardener without a clear evaluation of greenhouse types and gives no recommendations of what to look for in a glasshouse.

Of the remaining areas of discussion, Mr. Gardiner's expertise as a horticulturalist and true plantsman shows through. Those fifty years of experience in watching plants grow and reproduce has brought the amateur and professional gardener worthwhile tips on growing decorative plants.

Since the book was published before the ban on DDT, many of the pesticide recommendations are no longer applicable. More up-to-date recommendations are available from local Extension Service County Agents.

The information contained on these 214 pages gives details about plant culture that more technical books overlook; and, because of this one fact alone, I would recommend this book for the library shelf of any gardener.

Gerald B. Abrams

MORRIS ARBORETUM

SEPTEMBER 1973

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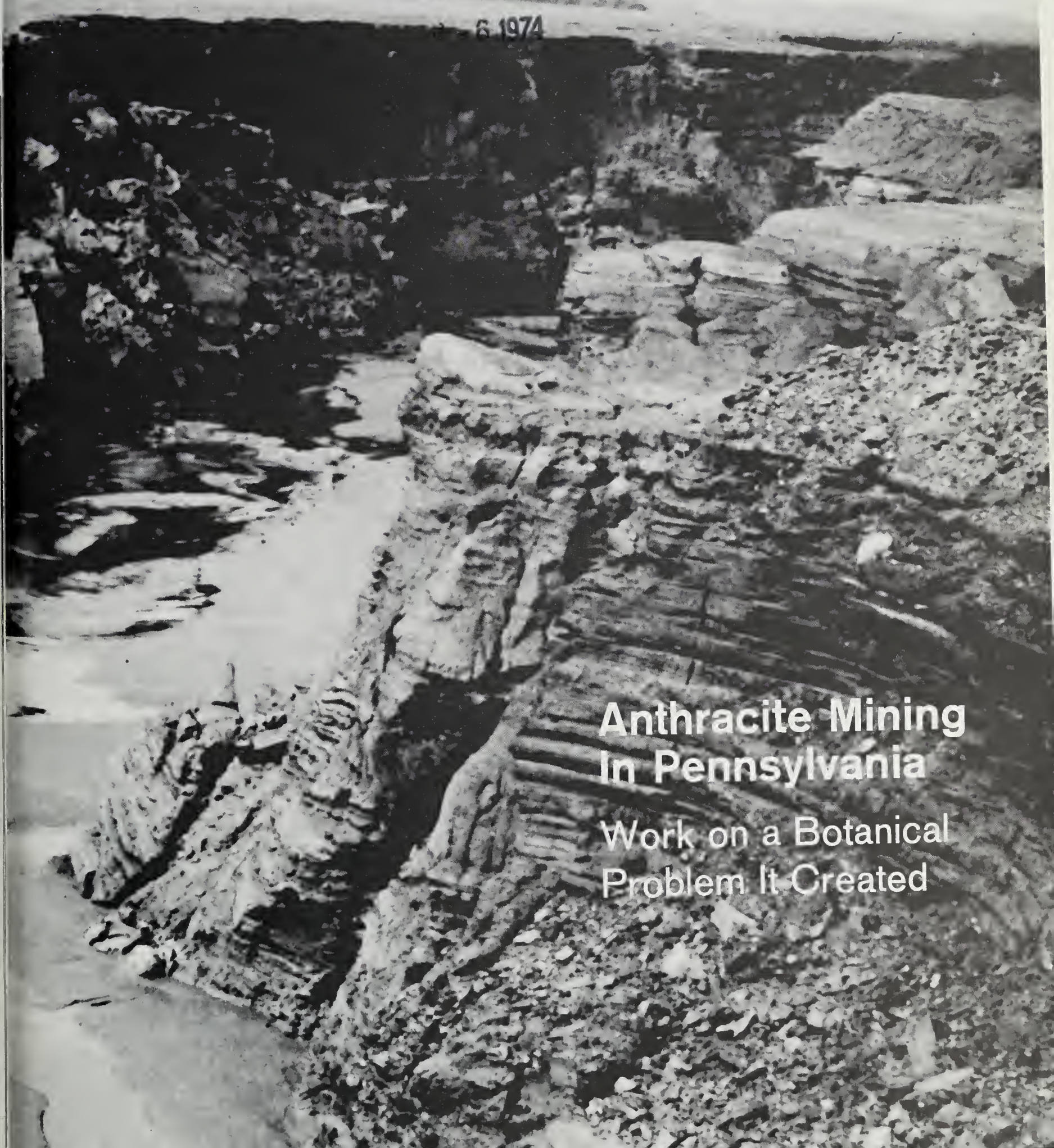

Anthracite Mining In Pennsylvania

Work on a Botanical Problem It Created

THE MORRIS ARBORETUM OF THE UNIVERSITY OF PENNSYLVANIA

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THE MORRIS ARBORETUM BULLETIN

Volume 24 Number 3, September, 1973

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COVER: Part of the environmental damage caused by strip mining in Pennsylvania. This canyon-like gully was formed after a retaining dam deteriorated. See article, page 41.

EDITOR: Hui-Lin Li ASSISTANT EDITOR: Susan B. Blum

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LORE of the ROWAN TREE

by Olga Lindberg

Olga Lindberg

The Mountain Ash, the Whispering tree, the Witchin' tree, the Quicken tree—all are folk names for the Rowan tree, that sturdy tree which grows best in rocky places and in the fall is laden with bunches of brilliant orange-red berries (pomes).

People down through the ages have placed a child-like faith in the power of this "Witchin'" trec to protect them from all kinds of misfortune. Stories of its strange mystic powers have been recorded in the folklore of many lands. It was believed that witches had no strength to do evil if there was Rowan wood nearby, so Rowan trees were planted by cottage doors and leafy branches hung over thresholds. Crosses made of Rowan wood were worn as charms or amulets. Sleeping with a branch of Rowan under the pillow was a sure way to keep witches away.

If a Rowan tree were planted in the church yard the whispering branches would frighten off evil spirits. Farmers wound branches of Rowan about the horns of their cattle to protect them from the black elves who often made cows go dry and got into the churn and prevented the butter from coming. In ancient times the Vikings' ships had a piece of Rowan wood in the bow to protect them from the God of the Sea, Ran, who was always hostile to sailors. Thus protected by Rowan branches these folk could face the uncertainties of life unafraid and undaunted by the evil spirits that lurked everywhere.

A legend in Finland tells of Ukko, the God of Thunder who was the mighty oak tree, and his wife, Akka, the pretty little Mountain Ash, whose shiny red berries were held sacred. The berries tasted of honey, and all who ate them became very cheerful, and if they ate three of the magic berries would become young again. No proof of this is on record but the people of Finland still cherish the Mountain Ash and in one of their epic poems say:

"In thc yard there grows a Rowan
Thou with reverend care should'st tend it."
Kalevala

The Rowan tree in England is known as the "Service" tree and in ancient times the berries were used to make a kind of beer called by the Latin name *Cerevisia* which has since been contracted to the English word "service."

Although called in America "the Mountain Ash," this tree is not a true Ash (*Fraxinus*). *Fraxinus* belongs to the Olive family, Oleaceae while the Rowan, *Sorbus aucuparia* L., is placed within the Rose family, Rosaceae. The Rowan is small within the tree kingdom, growing to about 40 to 45 feet in height. It has compound leaves formed of 9 to 15 oblong, toothed-margined leaflets. Many small white flowers appear in large clusters in the spring. These become the bright red berry-clusters in the fall. Each berry is round and approximately 1/3 of an inch across. The Rowan tree is a native of the mountains of Europe and western Asia. Its many horticultural forms have long been recognized and planted there as ornamcntals. The Rowan is also widely planted in North America, and has become naturalized in many areas.

The Mountain Ash has served humanity well for centuries—perhaps not in a practical way—but it has been a kind of psychological buffer against bad luck and misfortune. Many people, in many lands, have lived happier and more contented lives sheltered by the branches of a Rowan tree.

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1. Part of a refuse bank (32 acre area in foreground) of a colliery closed 1927. Dark woodland on left is an adjoining stand of *Pinus strobus* on native soil.

The devastation of land by strip mining stands out as one of the most destructive works done to our natural environment by modern man and his machinery. Reclaiming the vast regions of anthracite wasteland has become an urgent and crucial environmental problem in Pennsylvania. Various efforts done in the past have had little success. Dr. J. R. Schramm, Director of the Morris Arboretum from 1939 to 1954, had the foresight to research the ecological theories of plant colonization on these black wastes as far back as the early forties. For over twenty years he worked steadfastly in field and laboratory and succeeded, finally, in enfolding the basic problems underlying successful colonization.

The American Society of Botany in 1970 bestowed upon him its highest award for his monumental monograph, "Plant colonization studies on black wastes from anthracite mining in Pennsylvania," published in Transactions of the American Philosophical Society, New Series, Volume 56, Part 1, pp. 1-194, 1966.

We are indeed grateful that Dr. Schramm has been persuaded to write for us an article summarizing both this problem and his research findings in plain language for the general public. We hope that with this entreaty, the rehabilitation of these wastelands can now be implemented without further delay. The Morris Arboretum is ready to continue cooperating and contributing to this important problem.

For technical data and literature citations, interested readers are referred to the above mentioned monograph as well as to a related paper by Dr. Schramm, "The mechanism of frost heaving of tree seedlings," Proceedings of the American Philosophical Society, Volume 102, No. 4, pp. 333-350, 1958.

H. L. Li

ANTHRACITE MINING IN PENNSYLVANIA

WORK ON A BOTANICAL PROBLEM IT CREATED

by J. R. Schramm

Research Scholar, Department of Plant Sciences, Indiana University

For well over a century anthracite mining in Pennsylvania was essentially underground, coal veins being exploited from vertical shafts, horizontal drifts, and diagonal slopes. With the development of mobile earth-moving machinery, especially in the present century, coal veins began to be worked from the surface by removing the overburden of soil and rock. As more and more powerful equipment became available this surface exploitation ("strip mining") grew in importance because it became economically possible to uncover coal veins to increasing depths. In many areas of the Pennsylvania anthracite region "stripping" has largely or entirely superceded underground operations.

This transition ushered in fundamental changes in the nature, volume, and distribution of debris. In underground mining the refuse from the "breakers" (where raw coal is refined) accumulated about the collieries in great black masses (figure 1), disfiguring the towns and smaller communities that sprang up about these employment centers. In strip mining, the overburden is dumped beside the excavations that expose the coal in the usually strongly tilted veins. (figure 4). The ratio of overburden to raw coal recovered is vastly greater in a strip mining operation than the corresponding ratio in underground operations. Moreover, the stripped overburden is spread over much more territory; usually each coal vein strip mined leaves behind steep-sided embankments ("spoil banks") flanking the escavated trench. The wide ranging spoil banks, in the main, lack the close association with towns and other communities that is characteristic of wastes from underground operations.

Unlike debris from underground mining, which is predominantly black, the spoil banks from surface mining are generally light in color. This difference has important ecological consequences, as will appear later. To be sure, the raw coal recovered in strip mining yields black wastes like those from subsurface exploitation; but these accumulate about the breakers to which the raw coal is conveyed for processing.

Anthracite is—and always was—essentially a domestic fuel. Older refuse banks often contain substantial quantities of coal in the smaller sizes for which there was little demand; (furnaces and boilers were not adapted to their use). Developments have been such that smaller sizes are now in greater demand. This, plus the advent of powerful machinery and the introduction of highly improved coal recovery processes, has led to the reworking of older refuse accumulations (figure 28). But since the recoverable coal is generally a minor fraction of the original refuse, the final volume of black debris from even these reworked deposits remains very large. Reworking of sludge deposits also is widely done, but mainly by industry—as will be noted later.

The present study concerns exclusively the black wastes. These wastes are of two main types: (1) shaley rock from the breakers where the raw coal is refined; (2) fine coal and mineral particles washed

2. Barren refuse area with a pair of experimentally established pines: on right, a small *Pinus virginiana*; on left, a larger *P. regida.*

5. Vast sludge deposits contributing to stream silting by neglect. Early stage of gullying following break in retaining dam; in distance, sludge dust rising in mild wind.

3. *Inocybe* sp. mushrooms, an ectotrophic mycorhizal fungus under pines in figure 2. During a moist period nearly 1500 appeared under the two pines.

6. Discharge of sludge-laden water into settling basin.

4. Surface-mined ("stripped") strongly tilted coal vein (coal, on right slope, already removed), with overburden dumped on both sides ("spoil banks") of trench.

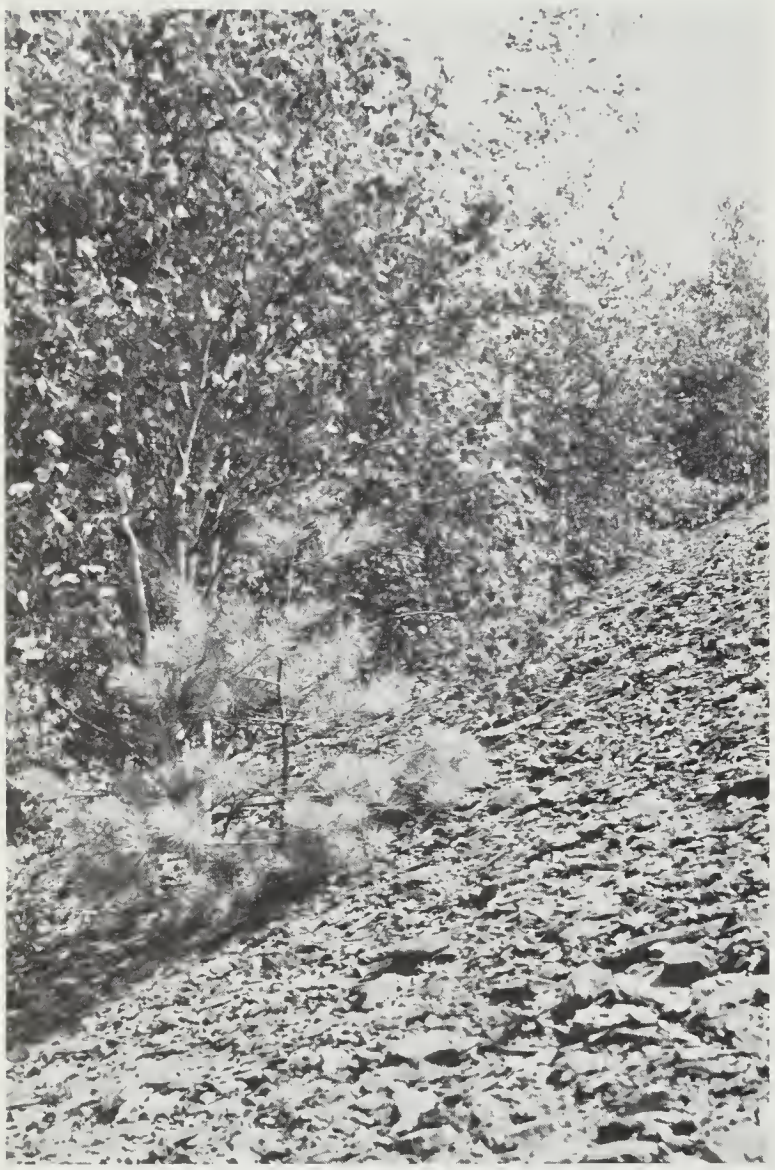
The anthracite area,
a ridge and valley region
once among the most attractive in the state,
is deeply scarred.

from processed anthracite before marketing. The former, "breaker refuse," accounts for the vast black banks and piles about collieries (figures 1 and 2); the latter, "sludge," now occurs in natural or artificial basins to which the water-suspensions are pumped from the breakers to reduce stream silting (see cover and figures 5, 6, 7).

The anthracite area, a ridge and valley region once among the most attractive of the state, thus is deeply scarred. This has come to have important economic, social, and aesthetic effects. With the introduction of new fuels anthracite markets sharply declined. New industries have not been attracted to the region in sufficient number and size to keep the economy at an acceptable level. Here the black wastes are especially significant because (a) they are at or close to communities, and (b) they colonize with plants so slowly, if at all, that even after many decades they may still be barren wastes.

7. The water, discharged into basin at far end (figure 6), spreading out in thin sheets and rivulets.

The few plants which here and there establish themselves naturally grow reasonably well and appear healthy. Why so few?



8. Naturally established *Pinus strobus* on steep northerly slope of refuse bank. Birches and aspens in background.

9. Naturally established *Melilotus alba* on refuse; in upper left, *Salix humilis.*

On the old refuse bank in figure 1 (32 acres of flat surface), the naturally established plants on the far left were in 1940: 1 black oak (figure 10), 1 sweet birch and 3 gray birches (figures 12, 13), 1 quaking aspen, 3 large-toothed aspens, and 1 shrubby willow (figure 9). Yet seeds, especially wind-borne, reach black wastes in enormous numbers. Eastern white pine (figure 1), immediately adjoining and favorably situated for wind distribution of its seeds to the black bank, failed utterly to establish a single plant in this locale. And sludge basins, especially those exposed to strong winds, usually remain without a single naturally established plant. But, considering the black wastes in general, the few plants which here and there establish themselves naturally, especially on northerly-facing slopes (figure 8), grow reasonably well and appear healthy. Why so few?

The most frequently invoked explanations for this refractory behavior of black wastes have been: (1) strong acidity, (2) nutrient deficiencies, and (3) aridity (insufficient water for the physiological needs of plants). These and, over the years, other factors affecting plant growth were studied both experimentally and by observation.

ACIDITY

Acidity (pH 4.8-5.0) of refuse and sludge was about that of adjoining natural soil (pH 4.8-5.2). Moreover, among the few plants occasionally establishing themselves naturally on black wastes (partial list in text above), there is no clear common denominator of high acid requirement or tolerance. The same proved true of species experimentally established, e.g., black locust and spiny locust (figures 14, 15). Acidity deserves more attention; but with clear evidence obtained meanwhile that barriers to spontaneous colonization lay elsewhere, it was not followed further.

10. Naturally established *Quercus velutina* (black oak) eight years old, on refuse.

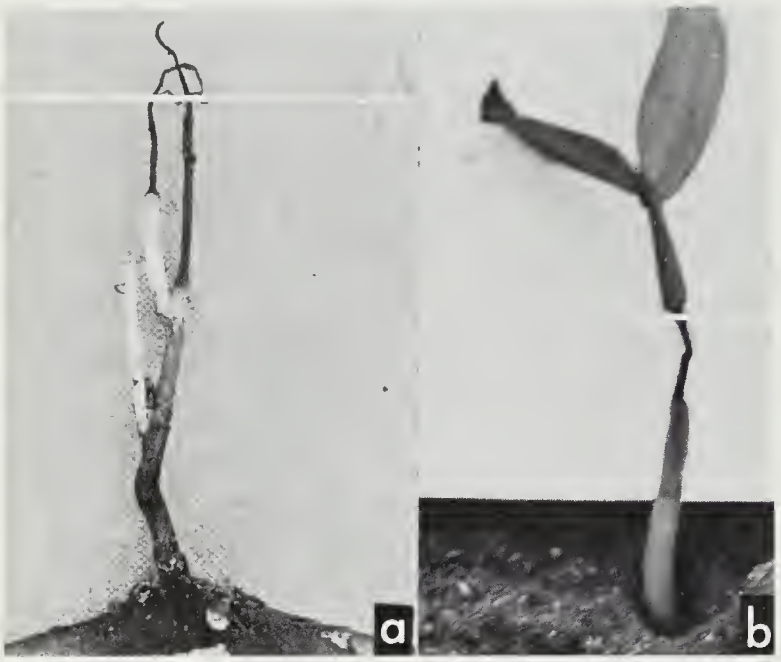
11. Trunk cut 15 years after tree in figure 10 was photographed.

12. Naturally established *Betula populifolia* on refuse bank. Plants in background artificially started.

13. Naturally established *Betula lenta* on refuse bank.

14. Legume *Robinia pseudoacacia* artificially established on refuse by seeding.

15. Legume *Robinia hispida* artificially established on refuse by transplants.



16. Heat killing patterns; (a) vegetative shoot (identity uncertain) from underground rhizome (at bottom); (b) from seed of sour gum (*Nyssa sylvatica*). Position of waste surfaces at horizontal lines; refuse removed for photographing. (a) Original shoot heat girdled at waste surface. Later and before second shoot started, the original shoot was again damaged and died down to the first node. The second (side) shoot started and barely emerged when it was heat killed ca. half the depth of the first shoot. The third shoot intact when excavated. (b) Emerged seedling fatally heat girdled at stem base destroying both cambium and phloem. Xylem temporarily supplying water to the leaves (cotyledons).

THE HEAT FACTOR

White and light-colored surfaces reflect much of the sunlight falling on them. Black surfaces, however, absorb a large part and convert (degrade) it into heat.[1] In consequence, the waste surface—when dry—becomes extraordinarily hot during central part of sunny days in the growing season. Temperatures up to 76° Centigrade (nearly 170° Fahrenheit) were measured. When it became clear that the heat factor was basic to an understanding of plant colonization of wastes, the physical aspects of heat distribution within and above the black wastes were studied experimentally.

Since it is the thin surface layer of the black wastes which absorbs the light energy and degrades it into heat, the surface reaches the highest temperatures. Below this surface region the wastes are heated primarily by conduction of heat generated at the surface. Thus the surface layer of black wastes is the most hazardous to young seedlings and shoots. Above this surface the heat gradient to the atmosphere decreases so rapidly that heat girdling of seedlings and shoots above the waste surface is scarcely measurable—occurring at heights no greater than approximately 1/16-1/8 inch. But below the waste surface the heat gradient decreases much more slowly so that heat girdling may reach 1/2 inch (rarely, even more) beneath the surface (figure 16). This accounts for the fact that the overwhelming majority of seedling and young shoot killings take place underground; the site of damage is not recognized unless the plants are excavated. To reach conclusions from surface appearances alone is a risky business.

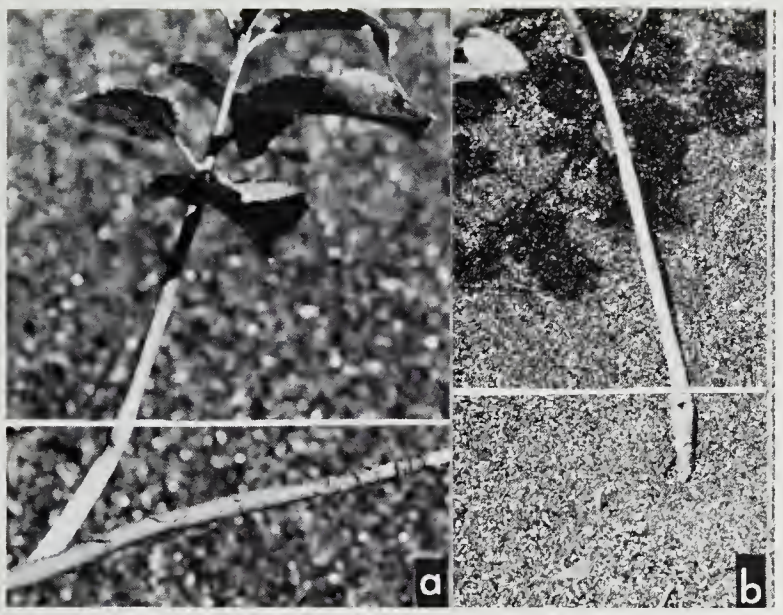
Occasionally the shadow cast by the thin stem of a spring pine seedling keeps the temperature of the waste surface on the northerly side of the seedling stem base below lethal levels. Later, more severe conditions may completely heat girdle the stem and end the struggle. But very rarely a seedling may receive no more heat girdling, repair the damage, and establish itself. In wider stems casting broader shadows, e.g., aspen root suckers (figure 17) this recovery is slightly more likely to happen. And when pine seedlings have survived successfully and are approximately two years old, the bark usually protects against further damage to cambium and phloem.[2]

In early June tiny spring aspen seedlings were noted on a bare sunny sludge deposit of a colliery closed some decades earlier. Their distribution was erratic—in irregular disjunct areas of a few square feet to some square yards in extent. Between these areas there were no living seedlings.[3] To the touch, the

[1]Sunlight is energy, and is neither hot nor cold. But when it is absorbed by, e.g., black wastes, and thereby degraded to heat, we commonly blame the sunlight directly. This basic difference between sunlight energy, and the heat of the black wastes induced by absorption of light energy at the surface, must be kept clearly in mind. The Arab peasant is unknowingly an applied physicist; he keeps reasonably comfortable in his long, loose and white galabia.

[2]Cambium is the delicate layer of cells between the wood and the bark which produces both the wood on its inside and the phloem on its outside. The wood conducts chiefly water; the phloem conducts the food, including that produced by photosynthesis in the green leaves. By pummeling a papaw or willow stem to make a boy's (or girl's?) whistle, the delicate cambium and phloem are crushed. Among other things, this permits the pushing in or out of the wood cylinder in the bark tube to alter the whistle's pitch.

[3]Progressing over the surface on hands and knees proved the easiest way to locate living seedlings, even with eyes closed. A grotesque technique, but effective.



17. Incomplete heat girdling of aspen root suckers: (a) Recent lesion on young sucker, narrow arc on northerly side uninjured; (b) sucker (seen from south side), partly heat girdled a year earlier, now nearly healed. Waste removed for photographing; original position of surfaces at cross lines.

populated and the barren sites contrasted sharply: the populated areas were much cooler, the barren areas definitely warmer or hot. Vertical cuts of the sludge disclosed that in the cooler areas (those with living seedlings) the sludge was fine-grained, keeping the moisture level close to the surface. In the hotter areas (those with no living seedlings), the moisture level was farther below the surface.

Sludge in water suspension is pumped from the breakers to settling basins (figures 6, 7). Here the larger particles settle first, yielding a coarse sludge. Beyond, the suspension spreads in shallow streamlets and sheets over the flat basin surface. As the sludge settles out textural differences indicating grain size become apparent. When the surface dries, the fine-grain regions retain moisture nearer the surface than do the coarser grained areas, with the former displaying lower temperatures, the latter higher. This accounts for the heat girdling of young spring seedlings at their stem bases, their near neighbors on the fine grain beds for the time being escaping injury. Later in the season, when heat potentials are higher, the earlier survivors may also disappear.

On refuse, sharp scrutiny also disclosed spring birch seedlings where the refuse was fine enough to be somewhat water-retentive (figure 18). As the season advanced and temperatures increased, almost inevitably the seedlings were heat girdled (when the surface was dry), and disappeared.

With heat effects clearly important in establishing plants on black wastes, the following factors were closely examined: (1) temperature gradients into black wastes as well as above the surface (atmosphere); (2) levels (contours) of sensible moisture and their effects on temperatures of waste surfaces; (3) angle of incidence of sunlight and it's influence on

18. Seedlings of *Betula populifolia* on refuse, June 1. Wind blew away fine particles, leaving coarser shale fragments on top. Below the latter, out of reach of winds, the finer water-retentive refuse is present.

A technique, "mass spot seeding,"
proved effective for establishing pines on bare flat refuse,
a habitat where isolated single seedlings almost invariably fail.

surface temperatures; (4) directional (compass) injury on plant stems; (5) effect of grain size of wastes on heat injury to plant stems. While technical details are not recorded here, it should be noted that lack of water is a critical factor, but only in the sense that drying of the wastes creates within them the physical system in which, under intense sunlight energy, lethal temperatures can and do develop.

Once passing intact the period of high susceptibility of seedling stems, pines are among the most successful of the few species succeeding on black wastes. And being evergreen, they are also most effective year-round in alleviating the unsightliness of the vast accumulations. Attention, therefore, was given to possible seeding procedures yielding microclimatic conditions under which pines might be established at minimum cost. (Transplanting pine plants is expensive.)

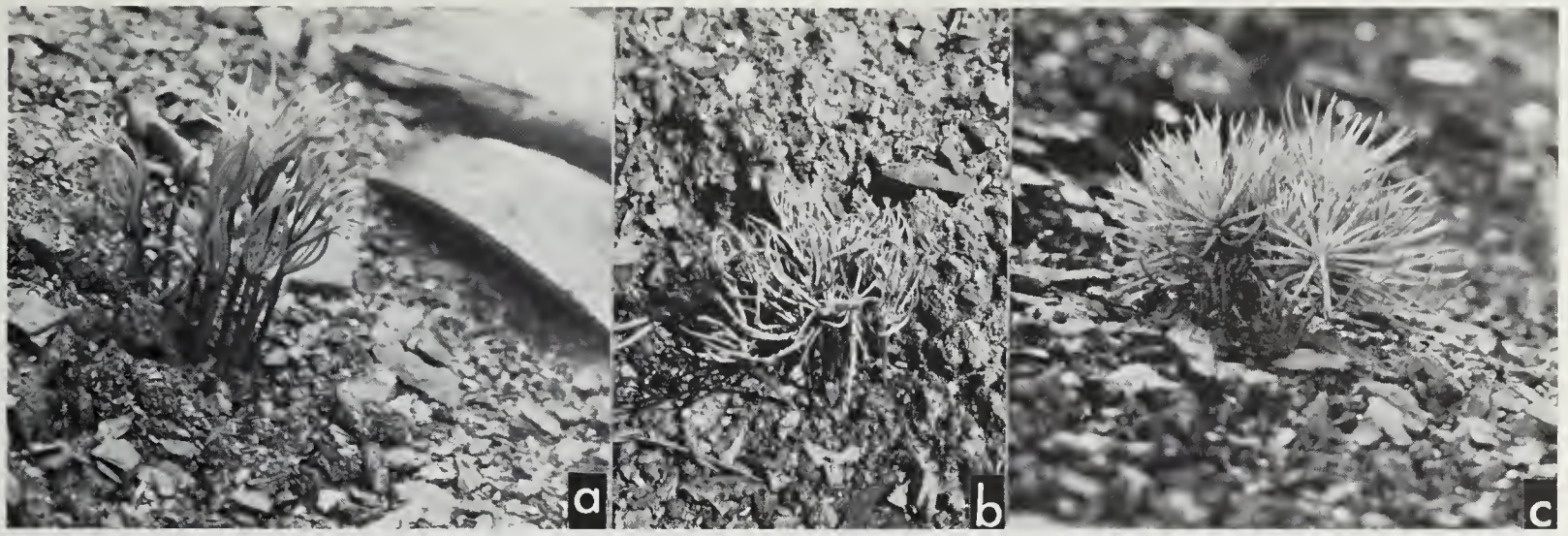
A technique, "mass spot seeding," proved effective for establishing pines on bare flat refuse, a habitat where isolated single seedlings almost invariably fail. In this technique seeds are planted in crowded groups to provide maximum shade for the stem bases of young seedlings. But rodents, as foresters and gardeners well know, rarely fail to find such tempting seed; certain birds and insects also are troublesome, either to the seeds or the young seedlings. For success, such losses must be prevented. Chemical agents are now available which are not injurious to the seeds, nor poisonous to wildlife; and these chemicals repel the unwelcome visitors.[1]

With such treated material, 25-35 seeds are planted in late autumn in one crowded group. By overwintering in black wastes the dormancy of seeds is broken, and germination in spring is maximally early. At this time temperatures are less likely to cause heat girdling. If these temperate conditions persist until the seedlings are erect and seed coats shed, the spreading and interlocking leaves (cotyledons) quickly form a canopy providing broken shade at the stem bases (figure 19a, b). Soon the peripheral seedlings in these crowded groups bend outwards, enlarging still more the waste area shaded at stem bases during critical hours (figure 19c). Barring accidents and in the general absence of serious frost heaving on refuse, such groups generally succeed (figure 22). That mutual shading of the waste surface about the stem bases is indeed responsible for the success of mass spot seeding is demonstrated by the success of isolated seedlings when the waste areas about their stem bases are shaded during hazardous hours (figure 20).

Rodent seed caches are essentially "mass spot seedings"—numbers of seeds buried in closely crowded groups in the autumn. And the provisions rodents fail to recover have much to tell us. Rodents apparently fail to bring seeds from normal soil areas and cache them in sharp refuse. Apparently they cache their provisions in refuse only when the seeds are obtained **on** the refuse and no natural soil is available nearby. Pine seeding experiments on refuse provided abundant seeds, and these received the rodents' attention. Six groups of pine seedlings resulting from caches the rodents failed to recover have appeared over the years (figure 21). If rodents were a bit less fastidious as to the soil for their seed caches, some colonization of pines on refuse surely would have resulted.

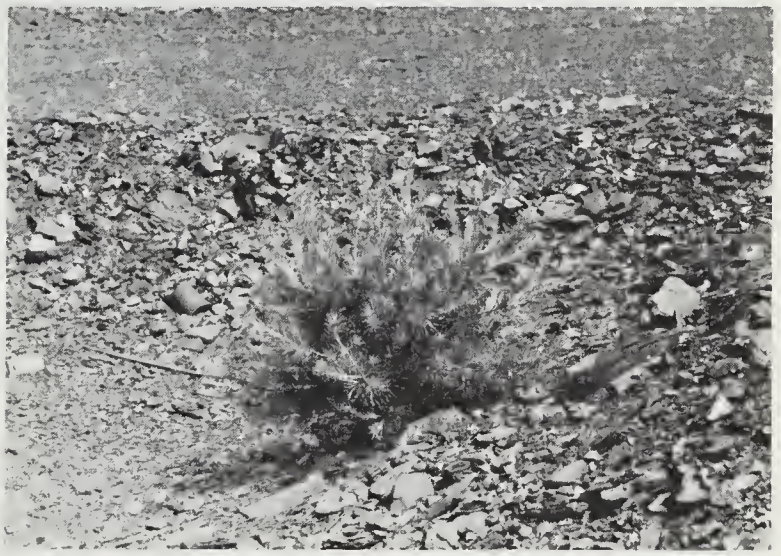
Birches naturally established on refuse commonly emerge from a small mound of shale fragments, frequently of a color different from the surrounding waste (figures 23, 24, 25). Removing the mound discloses a basal, more or less horizontal stem segment which carried the seedling apex past the edge of the shading black shale mass, the latter subsequently disintegrating to form the mound. Birch and aspen seed-

[1]Such treated seeds were provided by the Pennsylvania Department of Forests and Waters, (headquarters at Cressona, Pennsylvania), through the kindness of Mr. Nevin F. Slusser, District Forester.



19. Fall-sown "mass-spot seeding" of *Pinus strobus*. (a) Early May following; effective shade canopy as yet not formed, casting broken shade. (b) One week later, fair canopy formed. (c) Mid-July, stems bent outwards, simple true leaves formed, effective canopy functioning for some time.

20. *Pinus strobus* spaced-seedlings, shown one year from sowing, succeed in shaded north recess of rounded timber.



21. Crowded cluster of 15 *Pinus virginiana* plants four years old, cached by a rodent who failed to recover the seeds.

22. Detail within stand in figure 37. The pines (*Pinus regida, P. virginiana, P. banksiana, P. sylvestris*) were fifteen years old when photographed. Though many plants usually persist in the groups, one or two in each group become dominant.

23. Young *Betula populifolia* plant naturally established on refuse—as it appeared from the surface.

24. Plant in figure 23 after removing the mound.

lings, seemingly rooted at the edge of boards, timbers, etc., actually originated from seeds blown under the shading objects. Here, too, the history may be revealed only by disintegrating wood fragments. And where winds have carried off all remnants of whatever provided the original shade, the horizontal stem segment may be visible from the surface, demonstrating that the original establishment was in shade (figures 23, 24, 25). By and large, on black and level wastes, avoidance of strong direct sunlight is a *sine qua non* for survival and establishment of young seedlings.

On sludge basins exposed to strong winds the sludge particles raised may destroy both pine seedlings and transplants (figures 5, 26). On banks, including those not subject to strong blowing, drastic frost heaving may destroy the seedlings. Rooted

25. Naturally established *Betula populifolia* on refuse. At arrow, horizontal stem segment visible on surface.

26. *Pinus strobus*, in August, 1945, transplanted 1944 to a sludge deposit subject to high northerly winds. (a) Lower branches defoliated by blowing sludge; upper branches retaining a few needle tufts. (b) Bark destroyed to the wood on northwesterly side of stem (barely visible between first and second branch whorls in (a). Transplant died in 1945-46 winter.

27. *Pinus banksiana, P. rigida, P. virginiana, P. sylvestris, P. resinosa* transplanted as two-year nursery stock to sludge basin between picket fence windbreaks at right angles to prevailing northwesterly winds. Photographed 1946.

transplants, however, if protected from blowing sludge, avoid frost heaving. But since unprotected transplants may be destroyed by blowing sludge (figure 26), protection for a few years is essential for success on such banks (figures 27, 28).

But sludge deposits have been and are being used by industry. With improved methods of separating fine coal from mineral materials, the coal portion is finely ground, mixed with a bit of oil, and blown into boilers where it burns much like gas. Since sludge will essentially disappear, it's colonization by plants—which is practical (figures 27, 28)—will not be detailed further.

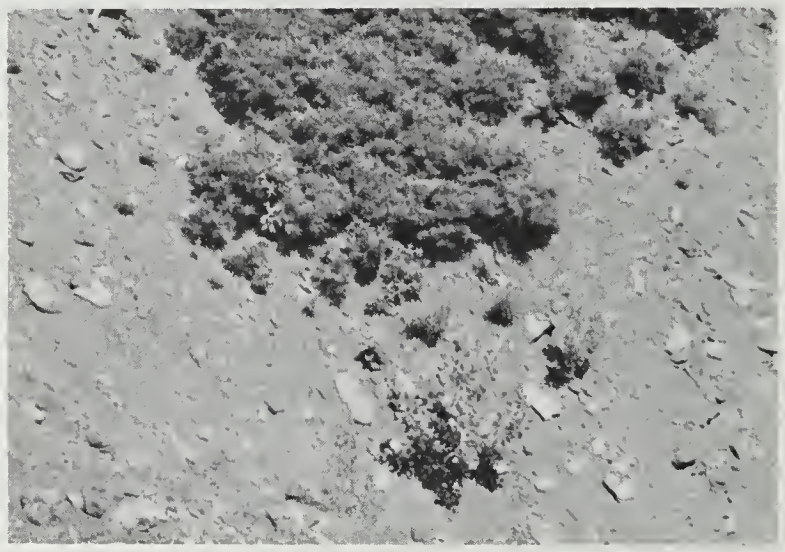
28. Photo from same point in 1958. All fence removed 1949-50. Slope in background of figure 27 is a refuse bank reworked later but before this figure was photographed.

THE NITROGEN FACTOR

From other experiments, illustrated in figure 31 but too lengthy to present here, it became clear that refuse is deficient in certain nitrogen compounds that plants require. Anthracite contains plenty of nitrogen, but not in compounds plants can use. Paraphrasing Coleridge's *Ancient Mariner*: "Water, water everywhere, but not a drop to drink". Phosphorus and other compounds essential for plant growth are present in black wastes in a usable form. Thus, the nitrogen deficiency in black wastes represents a major obstacle to plant growth. The problem is not insurmountable—as will be noted.

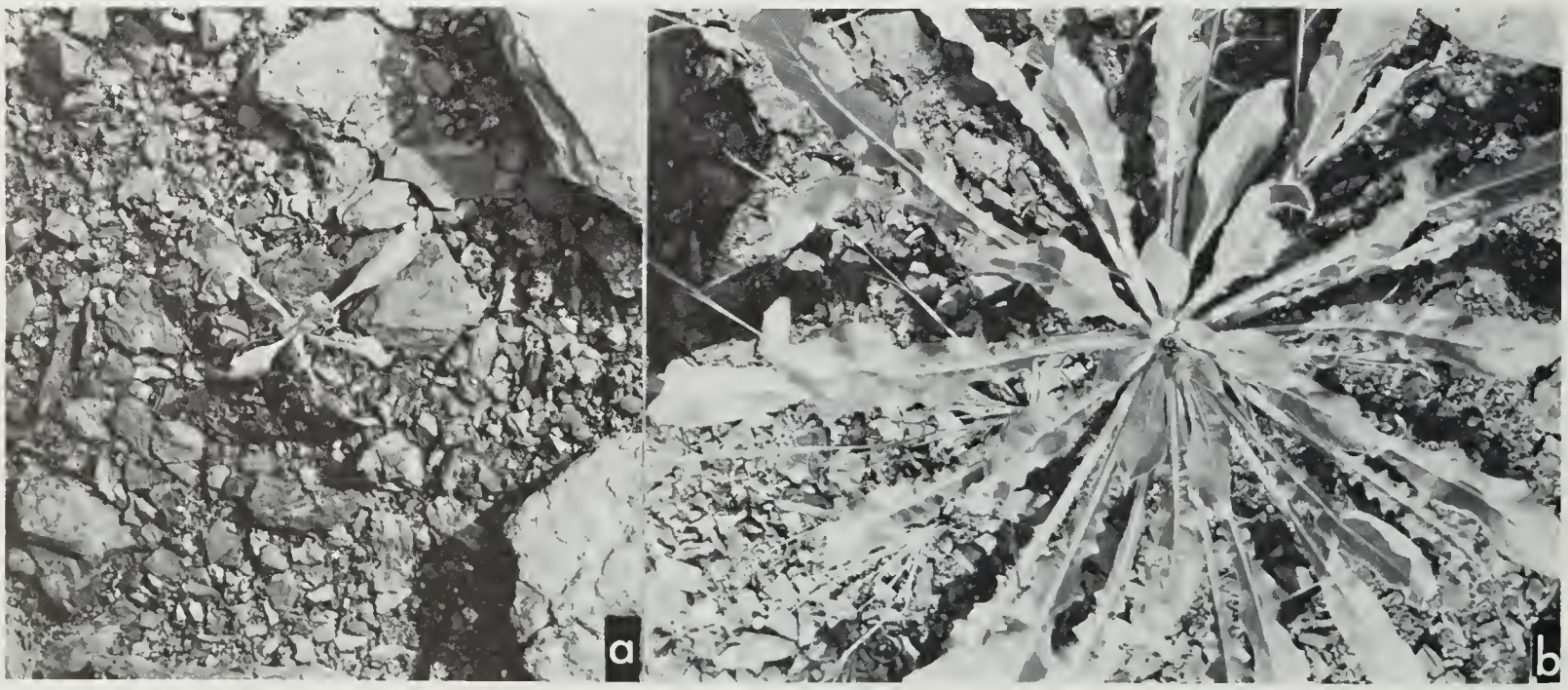
Considering spontaneous plant colonization of black wastes in the Pennsylvania anthracite area, one is struck not only by the scarcity of spontaneous development but also by the few native tree and shrub species within these areas. Only pines, birches, aspens, oaks, a shrubby willow (figure 8), sweet fern (figure 30), black locust, and spiny locust were found. Of these, gray and sweet birches (figures 12, 13) are the least rare colonizers. Of introduced foreign species, European alder and Siberian larch do well. Of herbaceous species, white sweet clover (figure 9) and a few other legumes occasionally are found. But the vast majority of native plants of woodlands and fields fail utterly to colonize black wastes, even when surface heat is controlled by shade. Again, why so few?

29. Root nodules of spiny locust (*Robinia hispida*), containing symbiotic bacteria which fix free (atmospheric) nitrogen.



30. Naturally established sweet fern (*Comptonia peregrina*) plants on steep northeasterly facing refuse slope.

31. Field experiment with first year plantlets of evening primrose (*Oenothera* sp.) on refuse. Size of the two plants the same as experiment started; leaves of both equally red, the latter apparently a symptom of deficient nitrogen. Control plant (a) received on alternate days 250 cc. of distilled water; the other (b) 250 cc. of 0.02 normal solution of sodium nitrate. Photographed on same scale two months later as experiment ended. Control plant (a) failed to grow and leaves were even more red; the nitrogen-nourished plant (b) grew vigorously, the leaves becoming green.



32. Small group of root nodules on sweet fern (*Comptonia peregrina*) containing symbiotic microorganism which fix free (atmospheric) nitrogen. For sweet fern plants, see figure 30.

33. Fine rhizomorphs of an ectomycorhizal fungus (*Pisolithus tinctorius*) spreading widely through refuse. These arose from and are connected with ectomycorhizae on *Pinus virginiana* roots (figure 34).

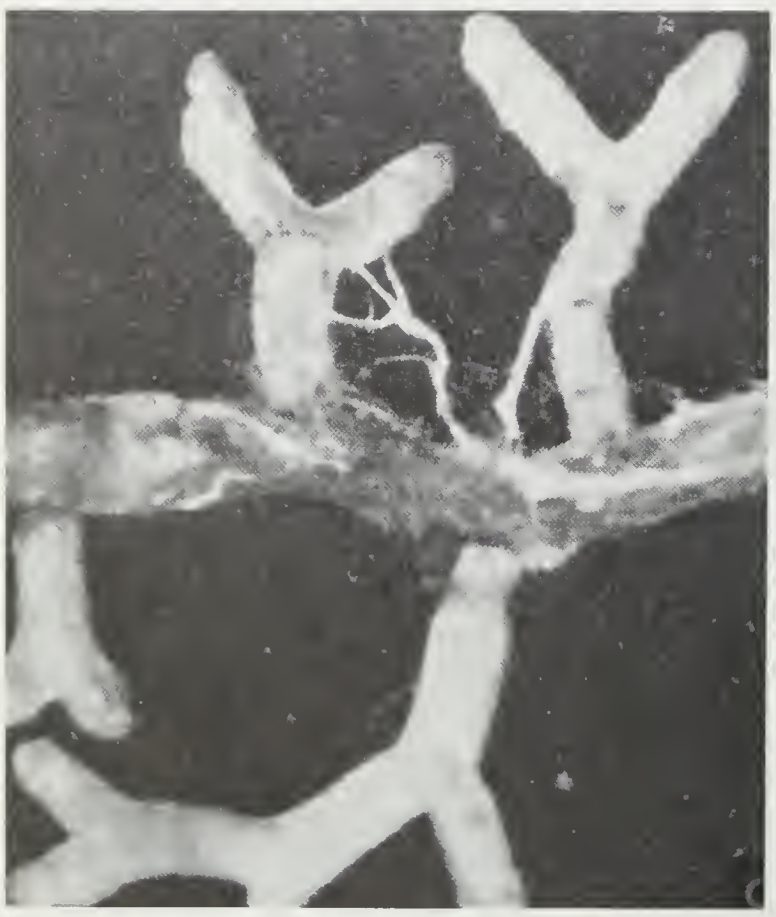
THE ROOT SYMBIOSIS FACTOR

In time it became clear that the few species colonizing black wastes either (1) possessed root nodules (figures 29, 30, 32) containing symbiotic bacteria or other symbiotic microorganisms which fix gaseous (atmospheric) nitrogen into compounds the host plants can use, or (2) formed ectotrophic mycorhizae —a relation established with certain fungi in which the fungus invades the absorbing rootlets only between the cells of the rootlet cortex, not into the cells.

These mycorhizae do not fix atmospheric nitrogen. But the fungi produce their vegetative structures: hyphae—minute hair-like elements consisting of a single row of cells (figure 35); and rhizomorphs—many hyphae in a single "rope" (figures 34, 35), which spread into the surrounding waste. It is well known from studies with radioactive compounds, that such compounds as the fungi absorb from the waste can enter the mycorhizal root cells. The result is that, of the substances absorbed by the fungus from the wastes (including usable nitrogen compounds present in such inadequate amounts), enough is supplied by the greatly enlarged and symbiotically organized root-fungus absorbing system to support reasonable growth. Meanwhile the fungus, lacking chlorophyll and unable to synthesize its own food, is totally dependent on the host plant. The latter, however, was made successful by the close and intricate cooperation of the dependent fungus.[1]

[1] Rarely on a waste bank, especially a shallow one, there may appear red maple (*Acer rubrum*), pin cherry (*Prunus pensylvanicum*), or staghorn sumac (*Rhus typhina*). These are neither ectomycorhizal nor nitrogen fixing plants. A thorough study of such a shallow bank, though planned, could not be carried out. But red maple was studied briefly. It is an endotrophic mycorhizal species, the fungus living within the cells of the root cortex, not between the cells. Unlike ectotrophic mycorhizal fungi, endotrophic ones produce no vegetative elements (hyphae or rhizomorphs) that invade the surrounding waste. Therefore they do not increase the absorbing area of the host plant's root system. Trials with red maple seedings never succeeded. Details are omitted here; see, however, figure 31.

34. Arrow 1 points to the long pine root, arrow 3 to a fungus mantle over the absorbing pine rootlets (the black objects on some mycorhizae are bits of coal still adhering to mantles). From the mantle the fungus sends hyphae into the root cortex, but only between the cortex cells. Arrow 2 points to fungus rhizomorphs attached to the mycorhizae. In becoming mycorhizae, the fungus stimulates the pine rootlets to divide into two equal branches (often repeatedly), and root hairs are suppressed. See figures 35, 36. Figures 33 and 34 present in barest outline the highly integrated, symbiotically organized, and successfully functioning root-fungus system.



35. Rhizomorphs of ectomycorhizal fungus (*Thelephora terrestris*) attached to mantles of pine mycorhizae. Note branching of pine rootlets (once in the two mycorhizae above the long pine root, three times in the large one below the long root).

36. A non-mycorhizal and starved pine root ("starved" due to insufficient available nitrogen compounds in refuse) with three stunted and unbranched absorbing rootlets, each with short sparse root hairs.

Here should bc added briefly a field experiment which ties together the heat, nitrogen, and root symbiotic factors facing pine or other young seedlings on black wastes. The seedlings came from seeds planted singly in refuse a year earlier. All had been completely heat girdled early in the first year, destroying both cambium and phloem. Then, as often happens, some of these seedlings lingered on, even through the first winter. In the second year the highly dwarfed leaves (needles) of the survivors turned increasingly yellow and growth ceased; the seedlings were clearly headed for death. The starved roots (figure 36) were then watered periodically with distilled water containing small amounts of inorganic nitrogen compounds which the seedlings could use—ammonium chloride or sodium nitrate (control plants received distilled water only). These nitrogen compounds reached the leaves since the water-conducting xylem still functioned. The seedlings gradually developed normal or near normal color and resumed a bit of growth. The leaves, by photosynthesis and subsequent processes, synthesized (among other things) suitable organic nitrogen compounds. But since the food-conducting phloem of the pine seedling was completely destroyed by heat girdling, these compounds could not reach the emaciated roots. The mycorhizal fungus, also in search of food, showed by actual observation no affinity whatever for the starved roots: the fungus faced an "empty cupboard." After the experiment ended in August, the seedlings gradually reverted to their morbid condition and eventually died. Excavating the seedlings revealed that they were without any mycorhizae.

The mycorhizal phenomcnon is an impressive example of a mutually advantageous relation established over the eons by two strikingly dissimilar plants: a green tree and a "root infecting" fungus lacking chlorophyll. Although this type of symbiosis was described (and interpreted correctly) in Europe nearly a century ago, it is only in the latter part of the present century that the basic significance of the mycorhizal relation has been recognized and increasingly studied.

Returning now to the botanical problem in the anthracite area in Pennsylvania. The black banks can be colonized, and colonized cheaply, by using treated seeds of ectotrophic mycorhizal species (e.g., pines) or nitrogen fixing plants (e.g., black locust), and planting them in the fall by a simple method taught us by rodents. And if pines are used, the offending refuse banks will be concealed in winter as well as in summer, in time developing into evergreen forested areas (figure 37). Knowing what plants succeed on black wastes, and especially why they succeed, we can start the colonization by planting treated seed in the autumn and—let nature take it's course.

37. Pines established on flat refuse by "mass-spot seeding" technique, a general view of figure 22.

shrub profiles

H. L. Li

ORIXA JAPONICA

Orixa japonica is a deciduous shrub with ornamental foliage. Its bright green shiny leaves with light colored, yellowish veins present a contrast to the usually darker foliage of most other shrubs.

The plant, commonly multi-stemmed with spreading branches, grows to a height of nine feet. The leaves are simple, short-stalked, ovate to obovate in shape, ranging 2 to 4½ inches in length and 3/4 to 3 inches in breadth. The leaves are alternately arranged on the nearly hairless stems, and are more or less bluntly pointed at the tip. Leaf margins are entire or very finely toothed.

A few whitish hairs line the veins on the leaf's underside. And when a leaf is crushed, minute semi-translucent glandular dots emit a faint, pungent odor.

Orixa japonica blooms from April to May. The plant is dioecious; that is, separate male and female flowers are borne on different individuals. These flowers are relatively small and not showy.

The male flowers, each with a stalk, are arranged in an elongated cluster (or raceme) growing laterally along the base of new branches. Each male flower has 4 sepals, 4 petals and 4 stamens. The female flowers are borne singly, each flower having 4 rudimentary stamens and 4 carpels. The fruit, appearing from July to August, is composed of 4 flattened greenish-brown carpels attached to each other at the base. Each carpel splits into 2 valves, and releases a roundish black seed. These seeds can be used for propagation, or the plant may be propagated from cuttings.

Orixa japonica Thunb. is the only species of the genus *Orixa*, a member of the Rue family, Rutaceae. It is native to eastern Asia—to Korea, Japan, and southern China—and is sometimes cultivated there. Orixa is generally found along hillsides under trees, but nowhere in its native range is it common.

In eastern Asia *Orixa japonica* is an important medicinal plant used as an antimalarial drug. Chemical studies have to date found a number of special alkaloids peculiar to this plant.

Orixa is recommended for planting in shady or semi-shady situations, particularly under large trees. Its sparkling green foliage lends a useful contrast when planted among other shrubbery and, as an ornamental foliage shrub, it is worthy of more attention in current landscaping than it has received.

Hui-Lin Li

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Koller

Ilex ciliospinosa *is part of the new landscaping at the entrance of Gates Hall.*

ILEX CILIOSPINOSA

Plants with tall slim habits are widely adaptable in modern landscapes and *Ilex ciliospinosa*, a recent addition to the Morris Collection, is such a plant. This holly, native to western China, grows to a mature height of 14-20 feet with a spread of approximately 3-4 feet. While introduced to American horticulture during the early 1900's this plant has been neglected to such a great extent that it has never been given a common name in the English language.

The small evergreen leaves are alternate, 1-1½ inches long with a dull, dark green color. The leaf margin is armed with 4 to 6 small spines on each side. Leaves persist for at least two years.

Male and female individuals exist separately. However, the female plant is reported to be polygamous and thus able to produce fruits without nearby male plants. The small greenish flowers appear in early May and occur on twigs of the previous season's growth. They are followed by large quantities of berries which occur even on very young plants. The branches are heavily clothed with fruit borne tightly along the twigs rather than in clusters. Fruit ripens to an intense bright red in mid-September, four weeks or more before the English and American hollies begin to show color. Berries remain decorative until well past Christmas.

This handsome plant adapts to a wide range of cultural conditions. It tolerates exposures from full sun to partial shade and soils can range from sand to clay but good drainage is essential. An important asset is resistance to serious insect and disease pests.

Koller

Disadvantages of this species seems to be the tendency to form weak crotch angles on major branches and the plant tends to become loose and open with age. Both of these conditions can be eliminated with periodic corrective pruning.

Propagation of this plant is easily accomplished by taking hardwood cuttings during late fall and early winter. The cuttings should be lightly wounded, treated with root inducing hormones and inserted in a medium of one-third peat and two-thirds perlite.

Possible uses of this plant include hedges, container plants, specimens and accent plants for the shrub or herbaceous border. This holly is a gem in the world of shrubs and has qualities which make it useful in almost any planting.

Gary L. Koller

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books

EVERGREENS; TREES; FLOWERING SHRUBS; ROSES. Encyclopedia of Gardening Series. TIME/LIFE Books. Chicago, Illinois. 1971.

As more people become aware of the unique qualities of this Earth and of their own small parcels of it, they long to know how to care for what they have, or how to augment, intelligently, the comfort and appearance of their homes' surroundings. The editors of TIME/LIFE Books have attempted to meet this need with the recently published **Encyclopedia of Gardening**. Of twelve titles so far received, the four having to do with woody plants have been selected for review because of their probable interest to Associates of the Arboretum.

Each has been written by James Underwood Crockett, with the advice and assistance of many well-known horticulturalists, and is generously illustrated not only with drawings but uncountable photographs of the quality we have come to expect of LIFE publications. In each, Mr. Crockett and his editors follow an established pattern: an introduction to a general group of plants; a chapter or two on selection, planting, and maintenance accompanied by clear diagrams; an "illustrated encyclopedia" of 95 to 130 paintings in color and half again as many descriptions of noteworthy plants; charts of characteristics as an aid toward identification and use; colored illustrations of insects and diseases; and—a feature of particular interest to this reviewer—credits for all photographs, diagrams, and paintings.

These four books also have in their appendices either the U.S.D.A. climate map (**Roses; Flowering Shrubs**) or one that divides mainland United States into ten distinct areas where similar weather prevails. Considering the vastness of this country, with its extremes of heat, cold, moisture, dryness, and soils, Mr. Crockett must have had great difficulty in his selection of plants, to include something for every climate, every need, every taste—a frustrating task indeed.

The volumes are not really encyclopedic, nor do I believe the neophyte gardener would want them to be. Directions for planting, pruning, and care in the first half of each book are, without exception, well done. Any gardener can profit from the good drawings and precise explanations. Inserted through the books are "Picture Essays" which are in fact portfolios of photographs. Many of these are not included in the contents, so their discovery comes as both surprise and treat.

These books, while they contain much meat, are really come-ons—enticements to delve into the many-faceted jewel that is serious horticulture. Ample bibliographies at the back of each indicate where to look for further information. There are no keys to identification here, nor are the many paintings botanical studies. Other works provide these specifics should you want them.

The layout of the many TIME/LIFE series is uniform, an inspired, totally flexible arrangement that must be original in the profession of book design. The 8½ x 11-inch pages have either two columns of close text or one broad column with an extra wide margin: white space used for a combination rubric and footnote. Want to know how to pickle green olives? make bayberry candles? concoct potpourri? Or how to tap a sugar maple for syrup? how silkworms operate? why cork floats? Or what lion manure (should you have any lying around) is good for? Look to the marginalia.

Evergreens covers narrow-leaved plants as well as those with broad leaves and usually showy bloom, many of them tropical. Special sections deal briefly with the importance of year-round foliage in good landscaping; the fun of topiaries; the centuries-old art of bonsai. The encyclopedic half displays excellent portraits of the conifers in particular, and contains so much information that you may find yourself foundering through the pines and spruces and the red-cedar-that-is-really-a-juniper. I wish that even half of these were possible to find in nurseries.

Trees is the counterpart of **Evergreens**: it tells of the deciduous species as they perform in this country. The second chapter is rich with brief but lovely studies of leaf forms, branch structure, seasonal bloom, fall fruit, and stunningly attractive close-ups of bark textures. Fall foliage color is reviewed over a 4-week period in sixteen pages. Few people realize that autumn in other countries can be relatively drab, for we in the eastern United States have an unequaled abundance of species that turn vivid colors at the approach of winter. Maps that accompany this section give the territory of native trees and suggest farther plantings of these as well as non-natives. Heed these maps with caution; sugar maple, for example, will not thrive in areas of prolonged summer. A tree out of its element will, in time, be a sick tree.

While the paintings in the encyclopedic half, done by ten illustrators, are quite attractive, to the plantsman's eye, discrepancies show up: *Acer platanoides* 'Crimson King,' described as red-leaved and pictured as red, is in fact maroon-black, without fall color; *Laburnum* X *watererii* shown with a broad head of growth, not vase-shaped as described and as it is; *Paulownia* pictured as flowering after leaves emerge when in fact it blooms on bare branches.

Flowering Shrubs has a special tie to the Morris Arboretum because its superb cover photo of *Enkianthus* and others in it were provided by Ruth McVaugh Allen, a former student and Associate of the Arboretum. The "picture essays" include photos of bloom for each of seven (split) seasons and another essay on fruiting shrubs that attract birds (omnivorous, hopefully, for seed-cracking birds are no deterrent to insects). Here one sees many examples of subtropic shrubs with what appears to be over-accentuation of the sterile-floreted hydrangeas.

One especially valuable essay tells, all too briefly, of the "shrub hunters," more appropriately, plant hunters, for these intrepid, determined people began their work centuries ago. Our gardens, indeed, our very economies are based upon their discoveries.

Roses, the only title about a single genus, is a sincere attempt to do justice to an immense subject. Some of the photographs startle the eye with close-up brilliance; others are soft-focus shots that please at first glance but are hardly worth a second. Always fascinating is evidence of how the rose has been revered since earliest civilizations. The essay, "Romance of the Rose," reflects Jean Gordon's research and deserves a separate chapter. Long charts of pests and diseases appear, conveniently, in Chapter 2 instead of in the Appendix.

The 97 paintings by Allianora Rosse that decorate the list of 344 clonal and species descriptions, while attractive, are of little use for identification. No idea of scale is given in the text, although measurements are. I can appreciate the need to reduce the portrait of a large rose but cannot understand why such a didimutive beauty like "Sweet Fairy" should be enlarged to twice its actual size.

Roses is really an appetizer to one great manifestation of nature's wonders. To whet your taste, Mr. Crockett has thoughtfully provided a list, by states, of the major rose gardens in this country, and a bibliography well worth following up.

Other titles in the series include **Annuals, Bulbs, Lawns, Landscaping, Lawns and Ground Covers, Vegetables and Fruits, Flowering Houseplants, Foliage Houseplants.** At bookstores they are $7.95 each; by subscription from TIME/LIFE Books in Chicago, $5.95 with shipping charge extra, should you care to acquire the complete set.

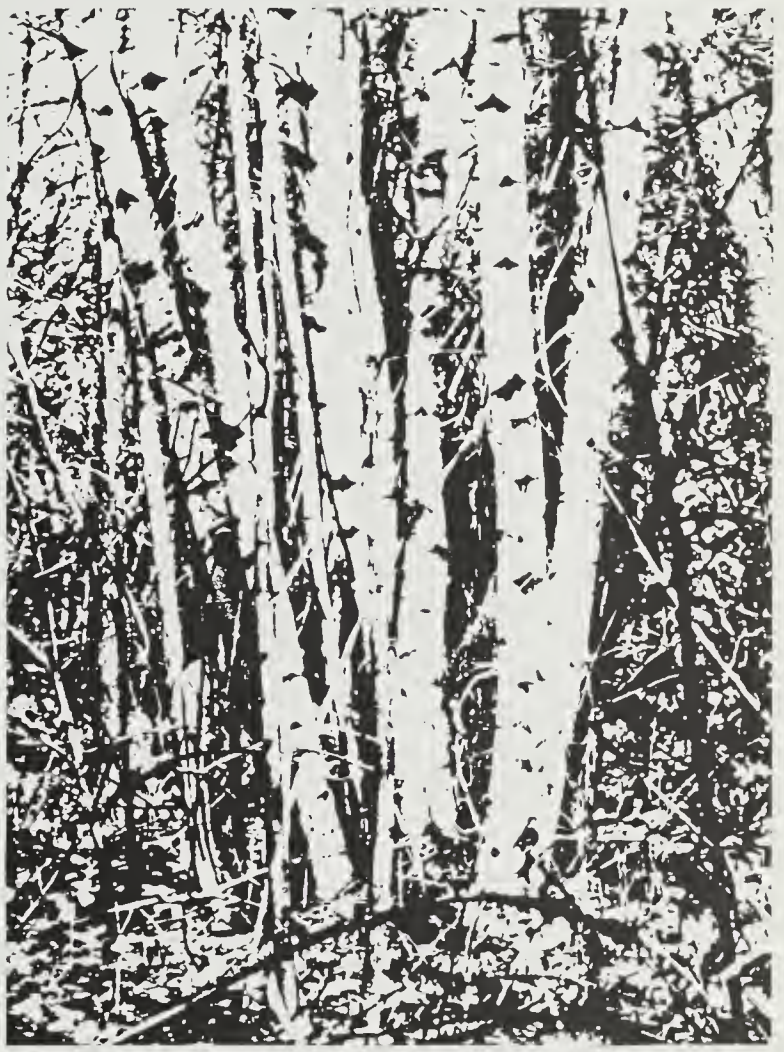
Leonie Bell

Leonie Bell graduated from the Ambler School of Horticulture for Women and worked for Mrs. Laura L. Barnes, founder of the Arboretum of the Barnes Foundation. She is well-known for her illustrations in Weeds of Lawn and Garden *by John M. Fogg.*

trees

of Pennsylvania
the atlantic states and the lake states

Hui-lin Li



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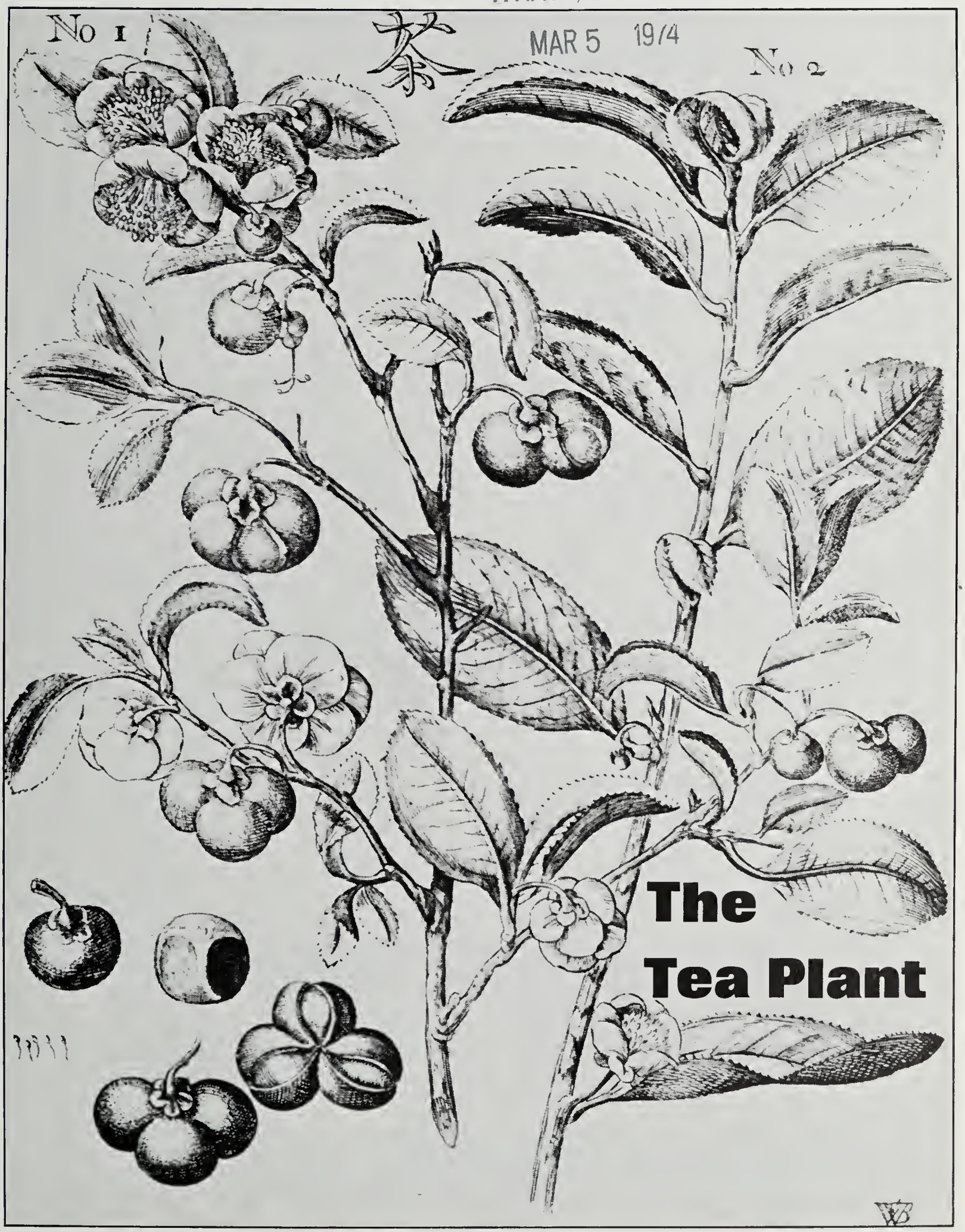

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THE MORRIS ARBORETUM BULLETIN

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COVER: *Camellia sinensis*, the tea plant, as illustrated by Engelbert Kaempfer in his *Amoenitatum Exoticarum*, 1712. Linnaeus' classification of this plant was based on Kaempfer's description. For more on the tea plant, see Shrub Profiles, page 67, and A Cup of History, page 68.

EDITOR: Hui-Lin Li ASSISTANT EDITOR: Susan B. Blum

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The RIVER and the WATERSHED

THE LAURA L. BARNES LECTURE FOR 1973

by Ruth Patrick
Chief Curator of Limnology
Francis Boyer Research Chair
Academy of Natural Sciences, Philadelphia

When our forefathers first came to this country they encountered watersheds covered with trees and, here and there, open meadows. The rain which fell upon these forests and open meadowlands seeped down through the forest floors to recharge the great underground water supplies. The hilly slopes and open plains were traversed with many small streams and rivulets. The larger rivers had strongly meandering courses as they wound their way to the sea. The smaller streams had white-water, riffle-pool sequences and less strong meanders. The flood plain was and is an integral part of each stream which is flooded at irregular intervals. The flooding of streams is as natural to the ecosystem as the falling of leaves from trees in the fall. It is this flooding that aids in the recharging of underground water systems and also builds up swamp areas and flood plain ponds which are a valuable resource for breeding and nursery grounds for many forms of aquatic life. Sediments deposited not only free the flooding waters of a heavy suspended solids load but also act as nourishment for the swampland vegetation.

Meandering is the natural course of flowing waters. The pattern of a stream channel has evolved over time and is the result of a quasi-equilibrium between the flowing water and its sediments, and the geological strata through which the stream flows. Indeed, it is a pattern of least work. Furthermore, this meandering pattern has a much greater capacity for storing water than does a straight flowing stream and thus evens out peak flows during flood periods.

Because of its large capacity for water storage, a meandering stream channel allows for greater assimilation of wastes within the stream course. The result is that water reaching downstream areas is of higher quality.

The assimilative capacity of a stream is made possible by the plants and animals that live within it. The decomposers, bacteria, fungi, and to some extent the invertebrates, take the debris that falls into a stream and utilize it as a source of food. In so doing these substances are broken down or transformed into soluble forms or small particulate matter which then can be utilized by other organisms and thus the wastes of one organism become the food of another. The primary producers—that is, the algae and the aquatic plants—utilize the dissolved nutrients produced by the decomposers as a source of food. These primary producers in turn become food for the herbivores, the protozoa, various invertebrates such as insects and molluscs, and fish. These herbivores are, in their turn, food for the carnivores. There maybe another level to the food web—that is, carnivores feeding on carnivores. Typically in aquatic ecosystems there are also omnivores which may feed directly upon the algae, herbivores, or carnivores. In these food webs there are many different phyla of animals which may function as herbivores, omnivores, or carnivores.

This complex web for the assimilation of wastes and the cycling of nutrients through the system exists in every natural stream. There are typically about four steps of energy transfer in this web. About 15 percent of the energy and nutrients fixed as algae is transferred to herbivores, and about 8 to 10 percent of the nutrients of the herbivores is transferred to carnivores. The stability of the system is fortified by the fact that functioning in each stage of energy or nutrient transfer are many species having a great many different types of ecological requirements. As the environment fluctuates there are always species present which can carry on these various important functions in the food web.

It was with the felling of the first trees by our forefathers that the story of the perturbation of the environment started in this country. As has been shown by Wark and Keller (Leopold 1968), cutting down the forest in the Potomac Basin—that is, reduc-

ing it from an eighty percent coverage to a ten percent coverage—increased the silt loads entering the stream by eight fold. Likens and Bormann* have also shown that cutting down the forest will increase the flow in the stream 380-414% (June to September). This increase in flow is due to the fact that the trees that formerly formed the forest transpired a great amount of water into the atmosphere. When they are destroyed the evaporation process from surfaces goes on, but the transpiration process is eliminated and therefore the flow in the stream increases. Thus flash flooding is increased by the cutting down of the forest. Likens and Bormann (1969) have also shown that the cutting down of the forest greatly increases the nitrates within the stream; that is, the nitrate concentration was 100 times as great in deforested watersheds. This increase is due to several factors. The tree vegetation no longer utilizes the nitrates, and the bacteria that transform or oxidize ammonia in the leaf litter into nitrates are greatly increased. Likewise, other ions such as calcium, magnesium, sodium, and potassium are more readily leached from the soil and enter the stream with the increased eroding sediment when the vegetation of the forest is removed.

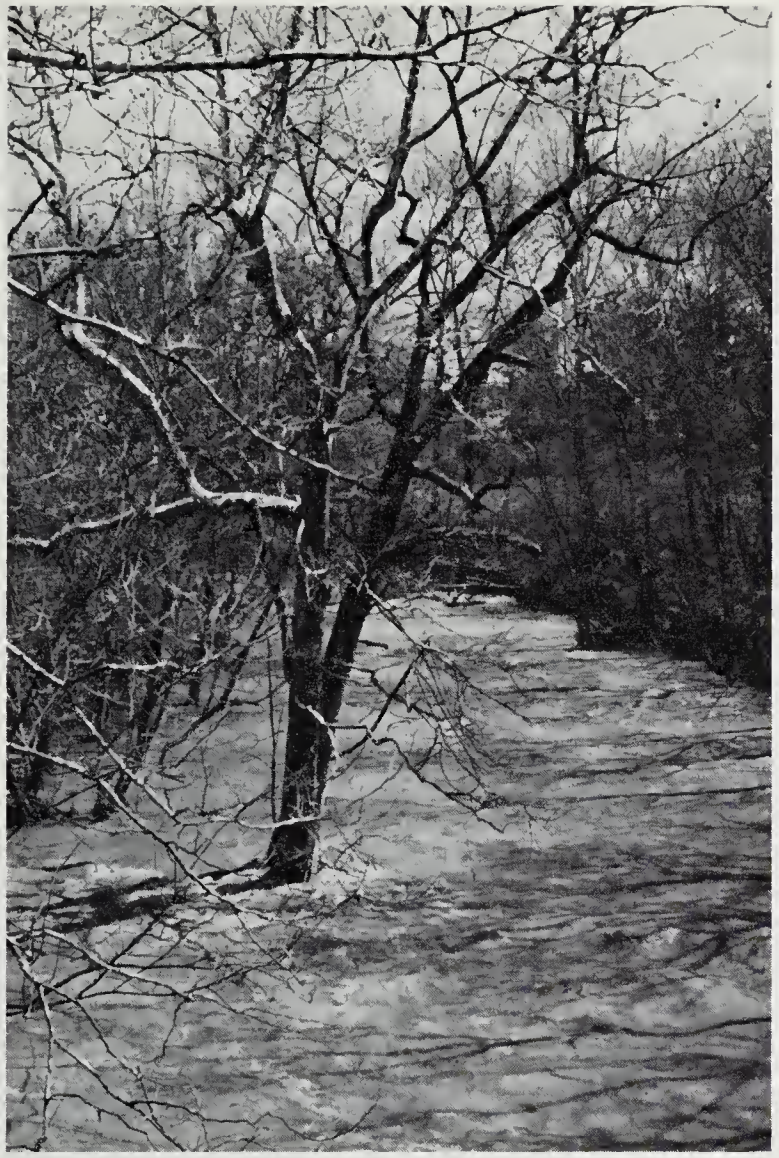
Increases in nutrients and sediment are also brought about by many other practices in the development of the rural community, in agriculture, and in urbanization. Wark and Keller have shown (Leopold 1968) that increasing row crops from 10 to 50 percent in the Potomac Basin (middle Atlantic States, U.S.A.) increased the sediment entering the stream fourfold. Work at the Academy's Stroud Water Research Center has also shown that the misapplication of fertilizer, particularly the fertilization of fields in winter when the ground is frozen, will often result in the leaching into streams of eight percent of the phosphorus applied to the soil. Industrialization and the sewage from concentrated populations and municipalities have also greatly increased the sediment and nutrient load in our streams. Recent studies in the Delaware Basin (middle Atlantic States, U.S.A.) have shown that about fifty percent of the sanitary wastes come from treatment plants and about fifty percent come from non-point discharges.

This increase in sediment and nutrients in a stream has many effects on the aquatic life in a stream. Suspended solids cut down the depth of light penetration, reducing the photosynthetic zone and thus limiting algal growth. These algae are not only important food sources but also produce oxygen through photosynthesis. Limiting their growth reduces the oxygen generated in the stream system and thereby reduces the stream's ability to restore oxygen used in respiration. Sediments also interfere with the obtaining of food by filter-feeding organisms such as caddisflies and mussels. It may also clog the breathing apparati of mayflies and stoneflies, or injure the gills of fish. When sediment settles out it fills the spaces between rocks in the stream bed and thus destroys the stream's natural roughness and diversity of habitat. The smoothness of the bed enhances the flow of water and thus changes the natural current patterns of the stream bed. The spawning grounds of fish which lay their eggs in the course sand of the stream bed are often destroyed, because the free circulation of oxygen and water through the sand is inhibited by the deposited silt.

Increased nutrients may have many effects upon aquatic life. If the nutrients are organic in nature they increase bacterial activity which in turn depletes the oxygen supply in the stream. If the nutrients are in mineralized forms, such as nitrates and phosphates, they may affect the kinds of species and sizes of populations of algae and other plants. If these added nutrients are in suitable amounts and ratios they may increase the productivity of many forms of aquatic life with the result that the stream becomes a better fishing stream. However, if the nutrients are not in the correct concentrations and ratios, as often happens downstream from sewage wastes, feedlots, and human habitations, there may be considerable change in the aquatic ecosystems. A shift in algal species occurs from those of high food value to those of little food value. As a result, predator pressure is reduced and large standing crops or nuisance growths develop. This type of shift may also occur in rooted aquatic plants. Sometimes these less desirable food species, such as some of the bluegreen algae, produce toxic substances which further reduce the viability of the food web.

The effects of urbanization have been further emphasized by the work of Wolman (Leopold 1968). The more people we have in concentrated areas the more highways are built to move them to and from their destinations. Wolman has estimated that the increased sediment load entering our streams eroding from the watershed during times of highway construction is 20,000 to 40,000 times that which would occur had the natural vegetation been left intact or had the area been denuded only as needed.

Leopold (1968) has shown that concreting over half of the watershed with rooftops, sidewalks, parking lots, and highways, and sewering fifty percent of the watershed increases the flash flooding of our streams. Indeed, a flood of any given height will occur about three times as often and the mean annual flood or any given flood will be 2.7 times as large. Thus man by his mismanagement of the watersheds has created the floods that now impose severe threats to his very existence. This dilemma is particularly



Courtesy R. Patrick

. . . flash flooding of stream.

true in the coastal zone where seventy percent of the population of the United States lives. In an effort to accomodate larger populations, people, along with industries and sewage treatment plants, have often moved into the flood plains. The flood plain, as stated above, is part of a stream system and is its buffer area to prevent the flooding of adjacent higher lands. It is therefore natural that industries and habitations on the flood plains will be flooded out. Man, in his attempts to control these floods, builds dams and channelizes streams.

The building of dams has many effects upon a natural river ecosystem. One of the most serious effects from the ecological standpoint is that it changes a free-flowing riverine system into a lake-riverine system which is unnatural and, as a result, bound to produce perturbation. The reservoir behind a dam may be useful for recreation. It also produces water in times of drought and may be a source of water for drinking and for various industrial and utility uses. But the question is—are these uses worth the economic, social, and ecological costs? They may be in some instances, but often the economic and ecological costs of attempting to prevent the flooding of the flood plains are too great to merit such uses. For example, water emerging from a dam often creates downstream erosion because water without sediments has more energy and tends to erode the downstream channel. Thus the natural characteristics of the channel and the stability of the riverbed are altered.

The water released from these dam structures is usually through deepwater gates. This deep water, particularly in the summer months, is very low if not depleted of oxygen. Many chemicals are more soluble in water with very low or no oxygen than they would be in well oxygenated water. As a result, the amount of metals, such as iron, manganese, copper, etc., is increased downstream. This shift in trace metal concentration may cause a change in species downstream and thus alter the natural food webs. The increase in these metals may also affect the desirability of the water for various industrial uses.

The lowered oxygen in the deep water of the reservoir also restricts downstream industrial use. If the oxygen content has been reduced by storage behind the dam, then subsequent use of the water by industry cannot be allowed if fish life is to be maintained. Likewise, the effect of municipal sewer discharges will be more severe if the oxygen content of the water is already very low.

It is well recognized by thoughtful people that man will probably never build a dam to accommodate the "100 year flood" because it would be so large that the costs of acquiring land and building the dam would be prohibitive. Thus he is only protecting himself against the small floods which would not be a problem if the flood plain were protected. If man would utilize the flood plain for the recreational purposes so badly needed by the increased population instead of building permanent edifices upon it, we would not only have aesthetically pleasing recreation sites, but the cost of protecting permanent edifices would be mitigated.

If these flood plains could be left in a natural state they would also regenerate underground water systems by allowing surface waters to seep slowly through their surfaces into the subterranean aquifers. In this way the supply of water throughout the watershed would be increased over time and the severe effects of drought, which greatly restrict stream flow, would not be so evident.

Another method commonly used to mitigate the effects of floods which man has created is channelization. Unthinkingly, man often straightens streams to increase the rate of runoff. In this process shallow water areas, such as the meanders and the backwaters and sloughs which are the most important feeding areas of aquatic life, are removed from the stream. This straightening process also reduces the water carrying capacity of a stream and increases the flash flooding in the receiving waters downstream. Flooding is not eliminated but simply transferred from one area to another. Furthermore, the assimilative capacity of the stream is greatly reduced and, as has happened in the channelization of Taylor Creek which

flows into Lake Okeechobee in Florida, nutrients that used to be assimilated in the creek before it was channelized now are assimilated in Lake Okeechobee. Thus the eutrophication of this great lake is further intensified by the channelization of some of its tributary streams.

In channelization the bed of the stream is dredged and often the banks are cleared. These practices inevitably result in an increased sediment load within the stream that in turn produces a shifting river bed which destroys valuable habitats for aquatic life.

The clearing of the stream banks destroys trees and shrub vegetation and reduces the shading of the stream. As a result water temperatures become much warmer during the summer months. Organisms which need moderate temperatures to complete their life cycles disappear and are replaced by warm water species. The arching trees over a stream also produce variable light patterns which enhance the diversity of habitats. Their leaves form valuable detrital food sources for aquatic life. The "fall-in" of terrestrial insects from the trees increases the food supply for fish. Thus the productivity and diversity of the stream is destroyed when over hanging vegatation is removed.

In the process of channelization clear-cutting of a 100-150 yard corridor along the stream is often carried out. This loss of bottomland forest will increase erosion and will destroy many of the habitats which are nursery and breeding grounds for organisms that live within the stream proper. Since these swamp areas and flood plains that are adjacent to streams often harbor many rare and endangered species their removal from the ecosystem severely reduces the pool of potential species to invade areas should ecological change occur. For an immediate need man often overlooks the long-term trends that are so important for the preservation of our ecosystem.

At the same time that man is unthinkingly destroying his natural environment for the development of his living space within the watershed, he is demanding higher and higher quality in regard to aesthetic values and water use. One of the most important reasons for this demand is the shorter work week. When man worked from sun to sun he cared little about the appearance of the Schuylkill or the Delaware Rivers, nor did he have any desire to water ski or have contact sports upon them. Also, today people are living longer and have more years of leisure in which to enjoy the acsthetics of the immediate environment about them which often includes walks along the stream bank or fishing within its waters. Thus, the common man is demanding a better environment. The energy crisis and the problems in mass transportation facing us in urban areas inevitably means that man must have recreation closer to home. Cities must have acceptable aesthetic areas for recreation that in former years were not demanded. We must seek ways to upgrade rather than to degrade or neglect the present urban environment.

These data clearly point to the need for wise planning of our watersheds. We must realize that open space and areas of recreation are an integral part of our life style. A watershed can reach its carrying capacity just as surely as can an elevator or an apartment house. We must carefully plan how people can be attracted to other areas of the country that are less densely populated. Also, we must learn how to recreate or restore areas that have been damaged. Recent studies on the physical and chemical demands of organisms have shown that adding minute amounts of chemicals such as trace metals to waters may have a great effect upon improving the productivity of food sources for fish. Likewise, the discharging of wastewaters so that current-patterns are created that are conducive rather than destructive to the development of aquatic life will do a great deal toward rehabilitating our streams.

Wise land management must be developed and then enforced to retain valuable top soil on the land. Such control measures would greatly decrease the need for dredging rivers in order to keep them open for ship travel. Programs of development should include better ways to develop highways without laying vast areas of land bare. Limits should be placed on the removal of surface vegetation by developers during construction. (Recent regulations in Pennsylvania will greatly reduce this problem.) More careful planning of roads should be carried out so that they do not inhibit the natural flow of waters. The flood plains should be maintained to control floods. Research should be carried out, as is being done by the Franklin Institute, Philadelphia, to create porous road and parking lot surfaces so that water may seep into the soil of the watershed where it is produced.

Man has a great deal of ingenuity and ability to manipulate his environment. But he has been very short-sighted in his development of land and water resources. He must carefully plan what he does for the impact of his acts could be devastating. The time has come when man must realize that he is but one animal in the earth's ecosystem and that his life and the life of his environment is dependent upon his correct planning and use of the biosphere.

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shrub profiles

While the tea plant is one of the more important economic plants of the world, it is also a highly ornamental one. It is native to Asia, growing in its warm temperate to subtropical regions, and is generally not hardy to the cold temperate regions of the world. In Philadelphia it was long considered not hardy. But one plant has survived in the open for many years at the Morris Arboretum. It is planted on a lower slope, well-protected on all sides by plant growth.

The tea plant was for many years called *Thea sinensis* L. It is botanically very close to the Camellias and it is now placed in the Camellia genus as *Camellia sinensis* (L.) O. Kuntze.* The plant differs from most other species of the genus primarily in its long-staked flowers with persistent calyx and hairy ovary.

Camellia sinensis grows as a shrub or small tree to about 40 feet in height. Its leaves are shiny, elliptic-lanceolate, 1.5 to 4 inches long, and bluntly toothed along the margins. The nodding white flowers are borne one to three in the axils of leaves on stalks about two-fifths of an inch long. The flowers are 1 to 1¼ inch across. The fruit is a small capsule containing one to six smooth, dark brown seeds. The flowers are produced mainly from October on, and sometimes into January.

THE TEA PLANT

CAMELLIA SINENSIS

By H. L. Li

In its native Asia the tea plant is widely cultivated. Two varieties are now distinguished: var. *sinensis*, the hardier plant cultivated throughout China for tea, and apparently indigenous; and var. *assamica*, a tenderer plant apparently indigenous to the warmer parts of Assam and Burma to Indo-China and southern China. The former, var. *sinensis*, has relatively narrower and generally smaller leaves. The latter, var. *assamica*, is a taller plant with larger and usually thinner leaves pointed at the tip. Either plant can be propagated from cuttings or seed.

Camellia sinensis is a bushy plant, much branched from the base. With its dark green, shiny foliage and showy white flowers blooming in the winter season, it is a highly ornamental plant. The tea plant can be grown indoors but, like other species of Camellias, it requires a cool greenhouse rather than a warm interior. In the out of doors in the Philadelphia area, plants of hardier strains have been able to survive the winter in protected situations.

While it will never be possible to establish the tea industry in the Philadelphia area, from an ornamental horticulture point of view *Camellia sinensis* is a novel plant worthy of the effort and risk of the sophisticated gardener.

*Sealy, J. R. 1958. A Revision of the Genus Camellia. Roy. Hort. Soc., London.

Commemorative stamp of the Bicentennial Series issued Boston, July 4, 1973.

A CUP OF HISTORY

by Hui-Lin Li and Susan B. Blum

This year, 1973, marks the two hundredth anniversary of the Boston Tea Party. This important incident in American history was, as all children know, the trigger of the American Revolution. It is a timely and memorial event to recall in 1973, as well as being an important prelude to the coming bicentennial celebration.

In history an incident, designed or accidental, may have great subsequent effect. It may alter the course of history for a nation, a people—even the world.

Legend has it that tea-drinking originated in 2737 B.C. The Emperor Shen Nung was seated before his campfire waiting for a cauldron of water to boil. The fire contained branches of a camellia-like tree growing nearby. Some charred leaves from these branches were lifted by a draft, then dropped into the rippling water. The Emperor might have removed these leaves but for the pleasant aroma they produced tumbling about in the water. The Emperor tasted the concoction. It was delicious! It was tea.

An accident. More truly, the myth of an accident. Yet, if the Chinese had not begun the tea drinking habit, which eventually became so popular and widespread throughout the world, one wonders whether the United States would have had a somewhat different history than it has today.

To be sure, the sentiment of revolution was very strong in 1773. And it is certain that the thirteen colonies would have eventually declared independence rather than remain a dominion of the United Kingdom. If there had been no Boston Tea Party something else would have taken its place. However, the fact that tea was the incendiary issue indicates the importance of tea in the economy and politics of that time. The significant role of tea in the American Revolution is only one of several such roles it has played in history around the world.

History is presented usually in terms of great personalities dominating the times. A history based on important plants reveals a different aspect of history. It exhibits the great importance and effect of plants on human life and culture.

Tea was first known in China, perhaps around the period of the Warring States (481-221 B.C.). The cultivation of the tea plant originated in the southwestern part of China in Szechuan and Yunnan provinces. Its initial use was as a medicinal plant and later as a beverage. The natural range of the plant may have been rather wide throughout China south of the Yangtze River. As the habit of tea drinking

spread eastward the cultivation of the plant, undoubtedly aided by plants grown spontaneously in many of the hilly regions of southern China, also spread. Thus the tea industry was established nearly throughout warm-temperate and subtropical China.

The universal and popular adoption of the tea plant in China was achieved during the Tang (618-906 A.D.) and Sung (960-1279 A.D.) dynasties. Tea profoundly affected the Chinese history in several ways. It gradually gained importance as a source of revenue and, toward the later years of the Sung dynasty, was one of the chief commodities for taxation at the national level. It became one of the most important export items, especially to the Tibetans in the west and the Huns and Mongols in the north. These nomadic peoples depended on animal meat and milk products as their main diet and the use of tea was found by them to be most helpful in soothing their digestive systems after so rich a meal. It soon became an indispensable item in their life. As such, tea was an excellent barter commodity in the trade for horses, then of utmost military importance to the Chinese.

Besides its economic impact, tea had a great cultural influence. The popularization of tea drinking extended to all levels, from upper class scholars down through the masses. Intensive tea use began with the intelligentsia—the scholars, Buddhist and Taoist priests, and high governmental officials. The famous treatise on tea, *Cha Ching* (Classic of Tea) by Lu Yu of the mid eighth century Tang dynasty, greatly stimulated its use. Tea drinking was performed with various ceremonial practices at social gatherings. It was used in connection with meditation sessions in temples. Its close connection with Ch'an (Zen) Buddhism aided in its introduction to Japan at the turn of the ninth century.

The adoption and cultivation of tea drinking by Buddhist priests indirectly effected a reconciliation between traditional Confucian thought and the meditational Buddhist school. From this reconciliation arose the Neo-Confucian school of philosophy in

–the story of tea.

The tea gardens at Shanghai as pictured in Two Visits to the Tea Countries of China *by Robert Fortune, 1853.*

the latter part of the Sung dynasty. It was this ideology which dominated Chinese philosophical thinking for nearly a thousand years.

Tea drinking among the masses gradually modified the daily life of the people. Teahouses became more and more common, eventually becoming the center of social life in both village and city. Tea drinking replaced wine drinking for many. The use of boiling water in preparing a tea infusion was a great hygienic by-product in a day when most water was of questionable purity. The practice of boiling water was unknown or unused by all other peoples of non-tea drinking countries, and it is beyond doubt that it accounted in some measure for the increase in population in China.

Tea drinking had profound economic and social effects not only in China, but also in Japan where tea drinking was first introduced by the Buddhist monk, Saicho, in 801 A.D. By the fifteenth century the tea ritual was fully constituted in Japan. It was through the tea ceremony that the burgeoning Zen school of philosophy found a perfect medium of expression.

The Japanese tea ceremony is a careful and elaborate celebration, yet neither careful nor elaborate in the usual sense. The building in which it is held, the decor, the utensils to be used, the actions of the participants, the mental attitude to be fostered and attained are all carefully proscribed. Yet within this total proscription of events runs the thread of spontaneity and naturalness so basic to Zen consciousness.

The Japanese author, Okakura, in his classical work, *The Book of Tea*, 1906, sensitively discoursed on the cultural influence of tea on the Japanese.

"Tea with us became more than an idealisation of the form of drinking; it is a religion of the art of life. The beverage grew to be an excuse for the worship of purity and refinement, a sacred function at which the host and guest joined to produce for that occasion the utmost beatitude of the mundane. The tea-room was an oasis in the dreary waste of existence where weary travellers could meet to drink from the common spring of art appreciation. The ceremony was an improvised drama whose plot was woven about the tea, the flowers, and the paintings. Not a colour to disturb the tone of the room, not a sound to mar the rhythm of things, not a gesture to obtrude on the harmony, not a word to break the unity of the surroundings, all movements to be performed simply and naturally,—such were the aims of the tea-ceremony. A subtle philosophy lay behind it all."

That philosophy was Zen, an outgrowth of the earlier Taoist school in China.

Tea plantations; a view in the black tea district. From Two Visits to the Tea Countries of China *by Robert Fortune, 1853.*

Tea was not distributed to other countries, either Asiatic or European, until the Europeans began to trade directly with the Far East in the seventeenth century. Tea reached Europe in two directions, the northern overland route through Siberia to Russia, and the southern sea route from the South China Sea and around Africa to Europe. The northern route carried with it to eastern Europe the northern pronunciation of the tea ideogram "cha." The southern route brought to western Europe the Fukien dialect of the same word, "tee." Hence the different European names for tea: "cha" in Slavic countries and "tea" or "tee" in western Europe.

Europeans soon adopted tea drinking with enthusiasm. Tea became one of the most sought after commodities, along with silk, porcelain, lacquer ware, objects of art and spices from the Celestial Empire. Several European maritime powers competed severely for the lucrative trade. Their struggle for supremacy

was a strong impetus in the development of the eolonialist ehapter of history.

This struggle among the European powers lay not only in dominating the trade itself, but also in eonquering lands overseas for the exploitation of natural resourees. Spiees were among the major produets sought by Europeans in their trade with the Far East, and their ehief ineentive for subjugating lands in tropieal areas.

These eolonizers later also tried to establish tea eultivation on a eommereial seale. Tea was first taken to Java by the Duteh about 1690 and to India by the British about 1780. In 1825 the Duteh imported seeds from Japan to Java and, during the following ten years, from China as well. The Duteh eolonial government in Java sent J. J. L. L. Jaeobson to China six times between 1827 and 1833 to obtain information on the eultivation and manufaeture of tea, and to reeruit skilled Chinese workmen.

By 1835 tea eultivation was well-established in Java. Until then the British East India Company had had a monopoly of the tea trade with China. When this eame to an end, the British deeided to grow tea in India. In 1834, G. J. Gordon was sent to China to obtain plants and seeds. Tea gardens were sueeessfully established with Chinese tea in the Himalayan distriets of Kumaon and Dehra Dun, but less sueeessfully in Assam and Madras. In 1848, Robert Fortune was sent to China with the explieit direetive to obtain, by honorable or dishonorable means, the finest varieties of tea. His two eolleeting trips produeed not only tea and eultivated ornamental plants, but several interesting aeeounts of his journeys as well:

A Journey to the Tea Countries of China, 1852.
Two Visits to the Tea Countries of China, 1853.
A Residence Among the Chinese, 1857.

In 1835 tea was diseovered growing wild in Assam and was sueeessfully used to establish tea eultivation in that eountry. By 1839 the tea of Assam was being shipped to London. *Assamica*, the botanieal name of the diseovery in India, was a southern variety of the tea speeies *Camellia sinensis*, and found to grow wild from southern China to Assam. The eultivation of *assamica* spread to Ceylon where, when its eoffee erop was attaeked by blight, the tea was planted in 1867. The Assam and "Hybrid" teas, rather than China tea, are now eultivated extensively in Assam, Ceylon, northern India, and Java. Produetion of tea for world trade in this area now far exeeeds that of China.

World tea trade, as mentioned above, was dominated by the British up to 1835. They also eonsumed more tea per eapita than any other people besides the Chinese and Japanese. The British earried their tea-loving habit with them to the New World when they landed as pilgrims along the east eoast of North Ameriea. Tea was an important eommodity in eolonial Ameriea. Its role played in the history of the founding of the United States was mentioned briefly at the beginning of this aeeount.

The eontribution of the tea plant to Ameriean history is, however, not limited to the Boston Tea Party ineident alone. Soon after the founding of the new republie the eountry was in great straits for laek of revenue resourees. World trade was virtually monopolized by British ships and merehants. The United States in order to establish its eommereial independenee had to find trade resourees: an unmonopolized port, and an item of value for exehange.

China was the one eountry of the Far East that had resisted European domination and monopoly. Though foreigners traded aeeording to rigid terms established by the Chinese, the port was open to all eallers and thus a possibility for the Amerieans.

But onee in the port, what would the Amerieans have to barter for the valued Chinese tea and silks? The Celestial Empire was not interested in most of the items the Yankees might proffer. It was known that the Chinese would aeeept only Spanish silver dollars or eertain delieaeies for the tables of the rieh.

The processing of tea leaves for consumption. The roasting of dried leaves can be seen in the background. From China Illustrated *by G. N. Wright, 1843.*

This presented a seemingly impossible situation for the struggling young nation. Hard eash was very searee. And most Ameriean merehants were already deeply in debt from the Revolutionary War. The delieacies desired by the Chinese eould be gleaned by the British and other maritime powers from their other dominions. Ameriea had little aeeess to shark fin and select bird nests.

Then someone had an idea. Hadn't the British merehants set the Indians to gathering a wild herb? And hadn't they said it was much prized by the Chinese? Little attention had been paid to this herb at the time. But it now seemed the only bright star on the horizon.

The plant whieh stepped into this economic breaeh was ginseng (*Panax quinquefolius*), native only to the Orient and northeastern North Ameriea. For eenturies ginseng had been imbued by the Chinese with almost mystical powers to extend life and renew vigor. It was said that this tiny plant would bring as mueh as $300 an ounee on the Chinese market.

Seizing this slim hope, the Yankee merehants set about eolleeting large quantities of dried ginseng. The first merehant ship, the *Harriet*, traded her cargo *en route* with a British ship for twiee its weight in tea. The bargaining power of ginseng was proven.

But it was the *Empress of China* who first raised the American flag in Canton harbor. On her return to New York she provided a twenty-five pereent profit to her investors. Trade with China indeed had commereial possibilities!

Furs were added to the trading stores. Silver eoin was mustered. And the ingenious New England eaptains soon found that items not desired by the Chinese, such as dried fish, soap, eandles and tobaeeo, eould be bartered along the way. The resultant silver eoin was then used in Canton for tea, silk, poreelain and laequerware.

And the China trade boomed. Every man who eould assemble the investment was buiding a ship. The returns from trading voyages were handsome—in the younger days as high as a hundred and twenty-five percent the original outlay. With the inelusion of fur pelts traded from the Indians, the returns sky-roeketed to three and four hundred pereent. With these odds investors weren't hard to find.

Within twenty years of the first shipment of ginseng Ameriea had beeome a serious rival in the arena of world trade. And that rivalry was soon to beeome suprcmacy.

By 1840 Amerieau trade with China had regularized. The boom was over. Tea, always the staple in trade with the Orient, now eomprised four-fifths of the returning eargo. Competition ran high between New York and London as to whieh market would get the piek of the new tea erop and deliver it first to port. It was the Yankee Clipper that cinched the race.

Ship builders had long been seeking a design that would eombine sleek lines for speed and the large burthen (earrying eapaeity) that would make these long voyages profitable. The Yankee Clipper was the outeome of this seareh. Its lines combined those of the Baltimore elipper sehooner and (of all things) the Singapore sampan. Its burthen was a healthy 750 tons. Its knife-blade hull cut the seas from New York to Canton in only eighty-one days.

When an Amerieau clipper arrived in a Chinese port the British tea merehants fought to obtain cargo spaee—at three times the price of English vessels—to dcliver their teas to London. The warm cup of tea on the British table was now being delivered by the Amerieau traders. History had eome full eirele from the night in Boston harbor.

The tea trade was elearly the making of our young country. It afforded politieal recognition in the world trade arena, amplified our naval power to a supremacy, and established the strong eommercial base so needed by a developing nation.

Tea is today one of our more important economic plants. It is used as a beverage plant by more people in the world than any other. It is a trade eommodity of great importanee and plays an important role in the economy of a number of countries.

The use of tea as a beverage has undergone eonsiderable ehange over the ages. Initially it was boiled in water and taken whole. Later it was boiled with other ingredients, with grains, nuts, oranges, or other sweets. The pouring of boiling water over the leaves and drinking only the infusion was a later development, originating in China and now a universal practice.

Modern times has seen the invention of the tea bag, and now, with the use of instant tea, we are entering another phase. Perhaps it is a desirable development for the industrialized world. But it seems that something in life is missing when one cannot enjoy a leisurely cup of tea, alone or with friends, in an amenable environment, at a time of one's ehoice. Choosing the tea, brewing it, sipping it to taste, and being refreshed by one of the most exquisite produets bestowed by nature is a pleasure we should not discard too quickly.

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books

SEEING WHAT PLANTS DO by Joan Elma Rahn
Atheneum. 1972. New York.

An arboretum is not only for adults. We also count children among our members and interested visitors. The book under review, *Seeing What Plants Do* by Joan Elma Rahn, provides a much needed item for these young "associates," an introduction to plant sciences for the young reader.

Writing for children requires specialized skill and knowledge, and Joan Elma Rahn shows her competency in both areas.

Ms. Rahn exhibits a thorough command of her subject matter, an item of particular importance in writing for children. The simplification of topic and approach, such as demanded by children and evidenced in this book, could only be accomplished by one with an in-depth knowledge of basic plant science.

Seeing What Plants Do also presents a total learning situation to children and embodies some of the best theories extant in the field of education.

Ms. Rahn's book is directed to the seven through ten year old child. It is written in such a way to be accessible to the novice reader: vocabulary is simple; terms are, for the most part, explained. And the concepts introduced are honed to an admirable simplicity.

The language of the book, while elementary, is purely scientific. The author is not afraid to use "real" words. In doing so she acknowledges a child's basic intelligence, for what is properly explained need not be sugar-coated.

An excellent example of this exists in Experiment 2, "Growing a Plant from a Seed." The author says in discussing the parts of a sprouted bean seed: "Between the cotyledons and the root is a stalk that you may want to call a stem, but it is a *hypocotyl. Hypo* means *below.* So the hypocotyl is the stalk below the cotyledons."

"Hypocotyl" is distinctly and forthwith de-mystified. It is now *the* name for that section of the plant. And she proceeds in like manner to introduce such terms as "endosperm," "petiole," "palmately lobed and pinnately lobed leaves" and "photosynthesis," to name but a few.

Perhaps most admirable of all is the format—a logically arranged progression of twenty-one experiments. Experiment is a technique of approaching the world that comes easily to children. It is what they do naturally—in touching, observing, trying out. Ms. Rahn has based her experiments on very simple concepts: Do plants need water to grow? or light? What part of a root grows? or a twig?

The procedures within the experiments are thoughtfully uncomplicated. The simple language and construction of these procedures, combined with the playful yet diagrammatic illustrations of Ginny Linville Winter, would allow a child to perform the experiments with a minimum of adult supervision.

The layout of this 58 page book is uncluttered and pleasing. The plan of the book is concise. An introduction hints at the various and manifold ways in which plants touch our lives (a child's favorite vegetables, the grass he plays on, the furniture he sits on, even the paper of the book itself). Chapter One, "Some Helpful Hints," describes some basic methods employed throughout the book. The twenty-one experiments begin with "Seeing the Plant in the Seed" and progress to "Growing Plants from Wild Seeds," (the latter illustrating the effects of over-wintering on seed germination).

Following the experiments is the "Answers" section. This contains comment and further information on the results of the experiments. This separation of answers from questions allows the child to see more truly the effects of his own actions.

The single-page conclusion encourages children to answer their further questions through experimentation.

Seeing What Plants Do falls short of excellence in only two areas. The author's sound policy of explaining new vocabulary is not followed in Chapter One. There, the terms vermiculite, germination, and liquid fertilizer are used, yet unexplained. Also, while the text is directed to the seven to ten year old, the illustrations picture children slightly younger. While this is not a major difficulty, a closer correlation of age levels in text and pictures might eliminate any possible confusion for the book purchaser or user.

One item may serve to summarize the sound rationale of *Seeing What Plants Do.* Within the conclusion the author explains why a control group is necessary in any further experiments the reader might design for himself. While the term "control group" is not used, its principle and importance is carefully outlined. Thus, while the child's interests and age level are being spoken to, he is being soundly equipped for his own adventures in observation.

Susan B. Blum

Insects Affecting Park and Woodland Trees by Ephraim Porter Felt. 1905.

THE BAGWORM IS AN ABSURD SUCCESS

by Patricia Allison

As a moth—and that is what it is reputed to be—the bagworm is a cowardly, ignominious failure; but as a problem solver, the little beast is an innovative genius.

Because of this evolutionary skill in changing life style in the face of many adversities, the pest (*Thyridopteryx ephemeraeformis* (Haw.)) is now present in our area in destructive numbers.

DEVELOPMENT OF THE MODEL MOTH

The thousands of species of moths on our continent generally have similar habits and patterns of development. Eggs are commonly laid in large hairy clusters. The larvae hatch hungry and stay that way. These "caterpillars" are among the worst pests of plants. Some feed on roots, some on stems and leaves, some on fruits. Here are the tent caterpillars, the gypsy moths, many leaf miners, the shoot moths, the armyworms, the cutworms, the codling moths, the leaf rollers and skeletonizers, the hornworms, and even some wood borers.

After growing to many times their original size, the larvae become quiescent armored pupae wrapped in silky cocoons. So sheltered, they transform themselves into winged adults of various sizes and ornamentation. These scarcely feed at all and, even then, consume only liquids. Their two pairs of wings are scaly, as are their stout, hairy bodies.

Many stratagems have developed to protect the moth through his life cycle. These insects usually overwinter in hidden niches as eggs or as larvae that are protected by hairs, silk, or varnishlike substances. The feeding caterpillars ward off disaster from marauding enemies through camouflage, or by presenting a fearsome pattern of hairs and colors, or by being downright poisonous[1]. Adult moths have their camouflage techniques too. In addition, a big help in avoiding birds is to fly at night. Another is to present an altered outline when at rest by holding the wings folded like a roof or even wrapped around their abdomens. Then too, should moths blunder into sticky spider webs, their chances for freedom are good because they can fly off leaving some of their scales behind them.

An extremely important characteristic of moths is that *they divide the large responsibilities of survival in this way*: The larva will be responsible for consuming abundant food and for growing rapidly; the adult will be responsible for mating, for dispersal to new areas, and for egg laying.

But the wily bagworm has been willing to sacrifice nearly all semblance of mothhood in evolving other ways to stay alive.

[1]See "Animals That Mimic Parts of Plants" by Michael H. Robinson in the *Morris Arboretum Bulletin*, vol. 21, pp. 51-58, 1970.

Plate I. Picture history of the Bagworm. 1, bag in winter; 2, same, female, showing old pupal case and eggs within; 3, eggs much enlarged; 4, new larva, much enlarged; 5, tiny larvae in cone-shaped covers, feeding on a twig; 6, young larva skeletonizing leaf; 7, older, stronger chewers in pendent bags, one hanging by its silk; 8, full-grown larva without bag; 9, a full-grown larva moving; 10, male pupa without bag; 11, female pupa; 12, female adult without pupal case and bag; 13, male adult; 14, bag of male. The empty pupal case protrudes at the bottom.

From *Insects Affecting Park and Woodland Trees* by Ephraim Porter Felt, 1905; after Riley.

THE STRANGE WAYS OF THE BAGWORM

The newly hatched, famished little larva puts in its appearance in mid May or June. Like its cousins, it has three pairs of legs on its thorax just behind its head, but unlike them, it carries its abdomen upright in the air. (Plate I, fig. 4) It is only about one-twentieth of an inch long, but its appetite is over three months long. In the course of continuous banqueting on the leaves of a tree it will grow in volume several hundredfold, and would become an ever more succulent tidbit for birds were it not for the evolution of an elaborate form of protection. No fancy spots or hairs for this caterpillar. Rather, it shall build a house.

Adherence to this stratagem leads inevitably to more problems. How can the larva make the house? It would have to be lightweight, exceedingly strong, mobile, and camouflaged, to say nothing of expansible. How can he get into it, carry it, park it, clean it?

Building and Entering

The infant caterpillar, in addition to appetite, has the ability to spin silk from its mouth. The larva cuts out bits of leaf and fastens them together into a narrow strap. One end it fastens to the leaf in front of itself on the right, the other on the left. The next two maneuvers are seemingly strange and very difficult (see figure this page). The caterpillar leans over the strap, lowers its head, and does a somersault under the strap. This leaves the larva lying on its back, feet in air, held to the leaf surface by the band. Then it turns over. (Why not crawl under in the first place? Because the soft bodied caterpillar could not hold the strap up over its head. Its legs are too short and it has no shoulders).

Expanding and Cleaning

Next, the larva adds more material underneath itself to complete the belt. After this it severs the connection with the leaf, and adds more silk and leaf bits at the front until the tube is long enough to hide in—aerial abdomen and all. When finished, the caterpillar can move off like a tiptoeing trash pile an eighth of an inch tall (Plate I: 4, 5, 6).

At first the larva is able to chew out mere bits of leaf or twig epidermis, but as it grows it takes bigger bites of leaf tissues, then veins as well. The bag grows also because the larva adds more and more silk and leaf pieces at the front end. Finally gravity takes over; the caterpillar can no longer carry either itself or its dwelling upright. Instead, he hangs on to the bottom of the leaf or twig with his feet. Alas, another problem—the real danger of dropping the house! Hooks on the small false legs of some of the abdominal segments take over the work of preventing that disaster. Hanging down does have its compensations; it makes for much tidier lodgings. Excrement and the four old skins shed while molting can be pushed out the hole at what has become the bottom.

What happens when molting time comes? The larva can scarcely climb out of its skin, hold on to its house, and grip the tree all at the same time. Instead, it fastens the bag to a twig with silk and closes up the top opening. In private, it can perform the awkward task of splitting the outgrown skin, wiggling out of it, and casting out the pieces.

Camouflaging and Moving

The camouflaging of the house is usually fortuitous. In nature it looks as if it were a part of the plant on which the insect feeds because it is adorned with bits of twigs and leaves from the plant itself, but shy, newly hatched captive larvae have been known to use anything at hand, even paper, cork, straw, leather, and paint chips.

As if the larvae had not already burdened themselves with unusual tasks, they now take over one of the *main species-survival responsibilities* of an adult moth: dispersal to new territory. Shall they leave the bag behind and crawl to another site? This would leave them vulnerable to predators, to say nothing of sunburn. Besides, the bag has yet other vital purposes to serve. So off they go, possessed of a prodigious wanderlust. If they are members of a gang that has only begun to feed on a tree, they simply move over to ungrazed territory; but if the gang is too numerous or have practically ruined a tree, it becomes necessary to descent to the ground on a filament of silk, walk away lugging the bag, and climb another tree. Can this insect count its fellows or recognize a tree from the ground? Perhaps. It is well known that female locusts "count." They detect overcrowding by discovering the higher than usual concentrations of male secretions about them. In any event, the bagworm larva has a powerful urge to climb and even has been observed to climb from a wastebasket up the slick sides of a metal desk.

There is yet another evolutionary development that favors the limited dispersal capabilities of the bagworm larvae. They make their travels, however slight, even more meaningful with their exceedingly broad appetites. Almost any tree will do, conifers and broadleaved ones alike. Even herbaceous plants have been consumed. Furthermore, they seem to be well adapted to town life. Perhaps this is because in an urban locale they escape parasites that are more prevalent in the wild, or perhaps smooth plantless roadways make travel to more distant trees easier.

The Perils of Pupation

By now it is August or September. So far, male and female larvae have solved their problems in much the same way. Both have prospered, but the female and its house have grown much larger. The bag of the male is about an inch long, but that of the female may be twice that measure. At last both caterpillars spin new silken linings for their bags, then turn themselves upside down inside them. Next, each one forms a horny pupal case around itself. There, head down, inside the pupal cases that are inside the bags, they will gradually change into adults. This takes about three weeks during which they may be dashed and battered by the rains and winds of late summer storms and pecked at by persistent birds. To assure a successful, albeit turbulent, adolescence it is imperative that a good parking place be found before it all begins.

What are the specifications of such a place? These will depend to some extent on the length of time the bags and their cargoes are to be stationary. Three weeks would seem to be minimum. Should pupation begin a little late, the important date might come embarrassingly close to leaf fall. As will be seen, some of the bags must be so placed that they will last not only through the rest of the summer, but through autumn, winter, and most of the spring as well.

The mature larvae have two significant capabilities. They can distinguish between a leaflet and a leaf, between a leaf blade and a leaf petiole, and between a petiole and a twig. By utilizing this knowledge, they anchor to a part of the plant that is not likely to be shed. Second, they spin plenty of the very best silk in attaching the bag to a twig. The silk is so strong that sometimes it persists long after the bagworm is gone and strangles the growing branch.

The Dilemmas of Adulthood

Fine as these larval houses have been, they do make it difficult for the emergence of an adult. The hard pupal case is challenge enough for most moths, but the bagworm must get out of the bag as well. The male found a way. The female either did not, or forgot; it stays in the bag for the rest of its life. Now, compared with the grave problems facing the male as a consequence of this excessive female timidity, getting out of the pupal case and the bag is simple.

Although the pupal case is quite hard, it is not completely rigid, and even though the bag is confining, it does have that hole in the bottom. The vigorous small male moth within the case is able to wiggle his abdomen about to such an extent that the head end of the pupal case is pushed out the hole in the bottom of the bag. Then he breaks open the pupal case and emerges to begin his brief problem-filled adulthood. He has wings like a moth, though nearly scaleless, and a black hairy moth body. He has eyes and feathery antennae similar to those of many other moths. He is swift of flight and sure of purpose.

Meanwhile, the much longer, obese, cylindrical female struggles half way out of her pupal case, but not out of the bag. Along the evolutionary path leading to strict seclusion she has strewn nearly all of her mothly appurtenances. Legs are gone. Antennae are gone. Even wings, scales and eyes are gone. But she retains a certain something, probably a scent, that lures the smaller male to her. And what does he see when he gets there? Possible part of her head at the bottom opening of the bag, but that is all. Invisible to him is the fore part of her pallid body that is covered by the bag; invisible also above that, the hind part of her body covered not only by the pupal case but the bag too. He is confronted not with a mate, but with a monumental obstacle.

It is neither possible to say here that the female's seclusion followed some profound changes that came about in male anatomy during this problem solving nor that the changes in male anatomy followed a gradual withdrawal from society on the part of the female. The facts remain that the species is anything but extinct and that the male, by means of altered genitalia, is able to go to extraordinary lengths in solving this last problem of contributing his sperm to her eggs. Task completed, without ever having viewed his partner, he flutters away and dies. The female moves backward and upward again into the pupal case and begins to lay her fertilized eggs. There will be 800 to 1000 of them packed above her as she gradually moves downward again. Finally, the slit in the pupal case closes somewhat behind her and she, a much diminished version of herself, struggles through the bottom of the bag and falls, dying, to the ground. Swinging overhead is the clutch of eggs within their multipurpose double covering. When May returns, the hungry young will emerge and begin to make their houses.

CONTROLLING THE PEST THAT EVOLUTION FAVORED

The evolutionary history of this remarkable creature has permitted it to persist in almost half of the United States. Its range extends from Massachusetts westward to Kansas and Texas and south to upper Florida. It experiences periods of unusual abundance as it did recently when specimens of spruce, bald cypress, arborvitae, pine, sycamore, maple, oak, and willow were partially defoliated. This will not matter much to the deciduous trees, but the evergreen conifers cannot withstand complete defoliation. Even the loss of all of the leaves on one side endangers them because unsightliness is not one of the goals of gardening. The worst depredations are in the southern portions of its range. Dr. Westcott reported, "I have seen miles of red cedars in Virginia and many arborvitae in Texas killed by bagworms, but never such total destruction in northern states."

There are at least a half dozen insect parasites that attack the bagworm during its somewhat vulnerable quiescent times as pupa or egg. Unfortunately, one of them attacks some beneficial insects also.

Man is better able to prevent serious outbreaks of this moth than are the parasites if he will make use of the knowledge of the life cycle supplied him by basic research. He can emulate the natural parasites by destroying the pupa or eggs through removal of the bags in late season and winter. To be able to do this he must first accept the fact that he, like other bagworm enemies, has been deceived by the bag. In the first place, he fails to see it because it is made of parts of the very plant being harmed. Second, he might be so unfamiliar with the appearance of plants such as spruce and arborvitae that he thinks the bags are perfectly normal plant parts and fails to associate their presence with foliar damage. This most important of all the evolutionary stratagems can be turned to advantage. Once viewed, the dangling sources of next year's pests are easily recognized and may be cut off during the long stationary phase beginning with pupation and ending with hatching.

Then too, knowledge of hatching time or the early observation of defoliation will let us take advantage of the larva's gluttony. However well protected from birds it may be, the caterpillar is no match for many types of insecticides applied to the foliage (malathion, diazinon, dimethoate, zectran, carbaryl, and others no longer in use such as DDT).

Of course nowadays, there is always the possibility that a synthetic pheromone will be developed to lure the male moth away from the sequestered female. After all those centuries of unique evolution it would seem a shame somehow.

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